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FEATURE ARTICLES

MATERIALS & METHODS MANUAL NO. 74

ENGINEERING FILE FACTS

DEPARTMENTS

NEXT MONTH: Copper-Base Die Castings . . . . Waxes for Industrial Use . . . . Resistance Welding Nickel . . . . Forming Polyethylene . . . . Colloidal Graphite as High Temperature Lubricant . . . . Corrosion Resistance of Steels to Liquid Metals . . . . Materials Used in Jet Engines . . . . Phosphate Coatings . . . . SALT BATHS FOR METAL PROCESSING (Materials & Methods Manual No. 75)

The Materials Outlook

The steel scrap situation continues to look bad. On the average, steel plants have 15 day's supply on hand—and inventories are not increasing. This backlog will not go through the winter and a serious scrap shortage looks certain to trim steel production. A committee of senior steel executives is heading a drive to hunt down scrap in (1) government operations (ships, arsenals, etc.); (2) industry (obsolete equipment); (3) auto graveyards; and (4) farm areas. The drive is not going after household scrap or tin cans. Chambers of Commerce will organize local committees, and steel salesmen will prod volunteers and get progress reports from fabricators.

A recent patent covers an improved method of producing clad metals, which are coming into more general use to conserve nickel, cobalt, chromium and columbium. The new procedure is being used to continuously bond chromium-nickel steel and copper to give a finished product that is soft and devoid of roll set, even when the sheet is coiled cold. The bonding is accomplished without materially reducing the thickness of the composite strip.

A process to replace nickel with white brass alloy as a base for chromium finish is being adopted for production, although there are still technical obstacles to be overcome. An 80/20 zinc-copper alloy is electrodeposited from a bright cyanide bath, and the final chromium plate makes the coating indistinguishable in brightness and color from the conventional nickel-chromium coating, according to the developing laboratory. The preliminary research done before World War II was taken up again when the present nickel shortage hit.

Porcelain enamel is appearing in an increasing number of industrial applications as a substitute for stainless steel. The enamel not only resists corrosion, but the smooth surface is easy to clean, has a low coefficient of friction, and resists abrasion better than most steels. One of the latest applications is in a stripping column tray used in a distillation tower where styrene is removed from synthetic latex. Conveyor tubes and buckets, chutes, valve linings and exhaust mufflers are other recent applications. Porcelain enamel is also being used on high temperature surfaces, up to 1600 F.

Special high temperature problems are being solved with recently developed super refractories. Even moving parts—furnace rollers are one example—are being made of these new materials. Shapes up to 50 in. long with sections as thin as ½ in. are produced. Bonds with various special properties are tailored to fit the operating conditions that accompany temperatures up to 3000 F. Chemical stability, abrasion resistance and hot strength can be provided. Super refractories are not substitutes for fireclay brick—they

(Continued on page 4)

The Materials Outlook *(continued)*

are a class by themselves, replacing metals in many cases. Severe combinations of abrasion and corrosion have been solved even in room-temperature applications.

Carbon parts are getting a big play from designers having a hard time getting critical metals. Friction, temperature, arcing and corrosion problems are handled in bearings, molds, electrical contacts and seal rings. One big advantage is the wide spread of the properties available in the various forms of carbon. Many people who are turning to carbon parts in desperation are being pleasantly surprised by the actual advantages they have over metals and other non-metals in many applications. This is one place where the shortages will have some long-range good effects.

U. S. reliance on foreign sources for mica may soon be ended by a new company incorporated to make high grade mica electrical insulation from domestic scrap or small Moscovite Mica considered unusable up until now. A French process first used on a laboratory scale in 1943 will be used. A factory using this method is now in commercial production in France. Hand labor is almost entirely eliminated—chemical and heat treatment reduces the raw mica to a pulp, which is then formed into continuous, thin, coherent sheets by an adaption of conventional paper making techniques.

The big furor over the fabulous reduction in the price of titanium that the Navy claims is imminent is founded on some misconceptions. The electrolytic process that all the speculation is based on is still in the laboratory stage. No pilot plant has even been operated as yet. No one knows what the cost per pound of titanium will finally be. . . . One fact that is generally overlooked is that some of the principal producers of titanium, who have been in the business for quite a while and have plenty of marbles to play with, are losing money at present prices on both the sponge and the ingots.

Titanium's little brother, zirconium metal, which has been in the shade as far as the hoopla goes, may have more of a future than most engineers expect. The extraction processes for titanium and zirconium are almost identical, and if and when a cheap continuous process is worked out for titanium, the trap door will also open under the price of zirconium. By its chemical nature, zirconium will always be somewhat easier to get than titanium, and will always be cheaper. . . . Zirconium is not outstanding on high-temperature properties or on strength-to-weight ratio. Corrosion resistance is its strong point. Some conditions which dissolve titanium have no effect on zirconium. Sheets, bars and rods are now available for experimental applications.

One rolling mill alone — now being readied in Madison, Ill., — will increase our capacity for magnesium sheet by at least ten times our current capacity. The mill will be the first to continuously roll magnesium sheet on a production basis. The mill should be in full operation within the next year.

See page 7 for "Materials Control Orders"

Giant size hex nuts for a 250-ton hydraulic press are cut to shape by the oxyacetylene cutting process at General-American Transportation Co., Sharon, Pa. The cutting blowpipe mounted on an Oxweld Railroad Service Co. cutting machine easily slices through the 24-in. thick low-carbon steel billet. Cutting is accomplished at the rate of 3 in. per min. A hole was first cut out of the center of the block whose sides are then cut in the shape of a hexagon. After they are cut to shape, the hex nuts are threaded for column bolts in a hydraulic press. No other machining is necessary to complete these parts.

Probably the first man to work inside a jet engine is Harold Kirkendall, 31, who is shown here on the J-47 turbojet engine production line at General Electric's Lockland, Ohio, plant where he is employed as inspector of tail cones and after-burners. He is only 47 in. tall. Mr. Kirkendall's small size enables him to crawl into the afterburner and make general inspection, eliminating the original procedure of disassembling the elongated tail pipe before inspection. During World War II Mr. Kirkendall worked as a wing-tip assemblyman and inspector for aircraft manufacturers.

MATERIALS ENGINEERING News Digest

New Windshields Studied for Military Airplanes

Stronger, ice-free windshields for military airplanes may result from current research at the Armour Research Foundation of Illinois Institute of Technology.

The goal of the program is an electrically-heated, ice-free, failure-proof windshield. Foundation scientists will prepare specifications for aircraft manufacturers to follow in designing windshields, both standard and bullet-proof, for military planes. The researchers also are striving to develop a better method of mounting the windshields in the planes.

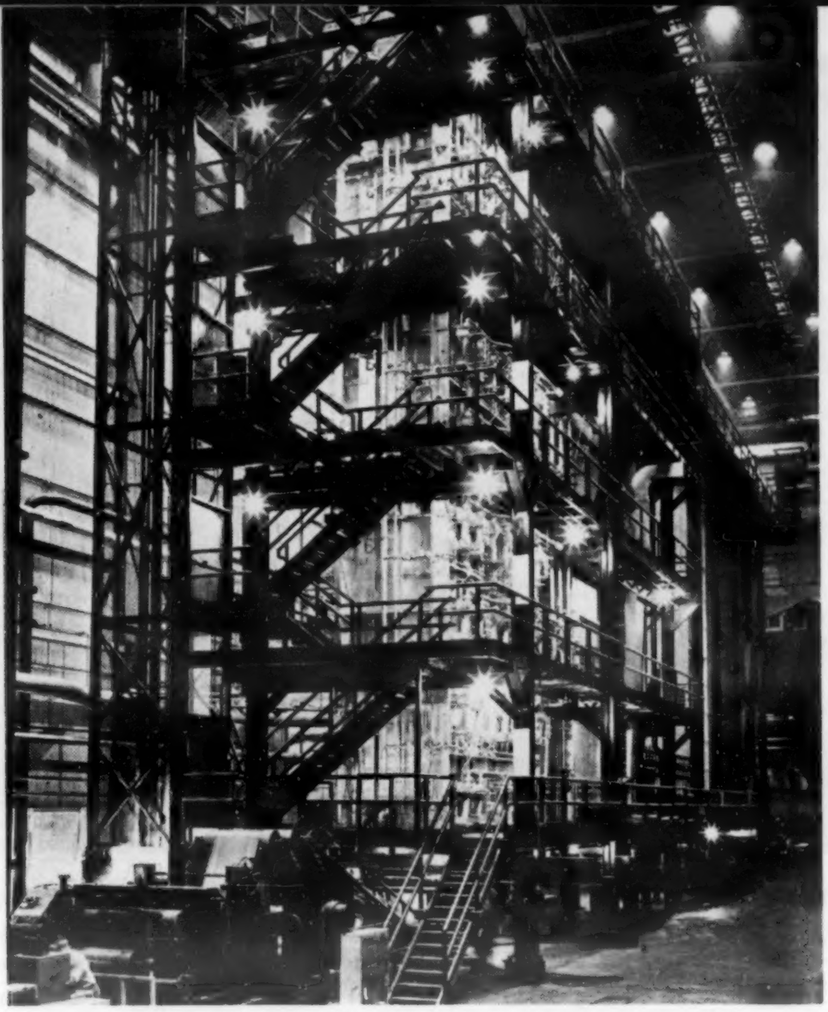
Since little has been written on how and why windshields fail, the first step was to compile data on weather conditions that a windshield meets in dry air, when flying into or through a cloud, and standing on the ground in sub-zero temperatures, soaking up cold (engineers call this "cold soak"). Using this data, Foundation experts made theoretical studies and devised laboratory tests to determine stresses occurring in a typical windshield in service. Their stress analysis studies were similar to those used by industry to achieve stronger, lighter machine parts.

In one test, alcohol, cooled to –90 F, passes across one side of a pane of glass. Heat, supplied by an electric current, is stepped up slowly on the other side until the temperature rises to about 500 F and the glass breaks. It's similar to the way a milk bottle breaks when boiling water is poured into it.

Although windshields will never meet these extreme temperatures, this new information on temperature differences and resultant failure will be valuable to designers and engineers.

Physical properties of glass and the plastic, polyvinyl butyral, also were evaluated in laboratory tests. Two layers of glass were bonded together with the plastic, somewhat in the manner of plywood, to make a laminated windshield. The researchers found that "cold-soaking" the plastic layer may cause the glass to fail. At normal temperatures, polyvinyl butyral is elastic, making it a valuable backing for the more brittle glass. At low temperatures, however, the plastic contracts and becomes stiff, sometimes cracking the glass and reducing visibility.

Another cause of windshield failure may be the "hot spot" created in the center when the windshield loses heat to the cold outer mounting. Heating the mount may answer this problem. The windshield's heat comes from an electric current, passed from the edge through a film of conductive stannic oxide between the outer layer of glass and the plastic. Keeping the temperature on the outer surface of the windshield at 40 F, so that no ice will form is the objective. The scientists must consider air friction, evaporation and other complex factors. They may use a thermostatic arrangement for controlling the heat in a final windshield design.



A new continuous annealing line has been put into operation at the tin mill division of United States Steel Co.'s Gary Sheet and Tin Mill. After cold reduction, tin plate is stiff and unyielding. To give it the pliability necessary for forming into cans, the material must be annealed. The line makes possible continuous annealing of steel for tin and black plate products in varying thicknesses, 18 to 37 in. wide, at a speed of approximately 1,000 ft per min. Construction of the line, which has an annual capacity of about 136,000 tons, was started almost a year ago. It is housed in a new building 336 ft long and with a ceiling height of 76 ft. The furnace section, equipped with combination gas and electrical heating units, is approximately 64 ft above the plant floor level. This installation is part of the overall program initiated by United States Steel Co. last year to increase the productive capacity of the Gary Sheet and Tin Mill.

Alloy Casting Institute Expands Research Program

Significant expansion of its technical research program is being undertaken by the Alloy Casting Institute to help meet mounting defense mobilization needs and other engineering and equipment requirements dependent on the use of stainless steel castings. Three new projects closely keyed to current production and supply problems of the industry and its customers are being instituted at major research laboratories.

In view of the greatly increased demand for high alloy castings and the concurrent shortages of alloying elements, the ACI Technical Research Committee is concentrating its alloy conservation studies at Battelle Memorial Institute on the high temperature properties of the 21 chromium, 10% nickel type alloy.

Similarly, development of titanium-stabilized corrosion resistant castings, important for use in expanding aircraft production, is being made the subject of an investigation to be carried out at Ohio State University.

In addition, an extensive study of improved gating systems for high alloy casting production will be conducted as part of the ACI program under way at Massachusetts Institute of Technology.

Research Engineers Delve Deeper into Corrosion at High Temperatures

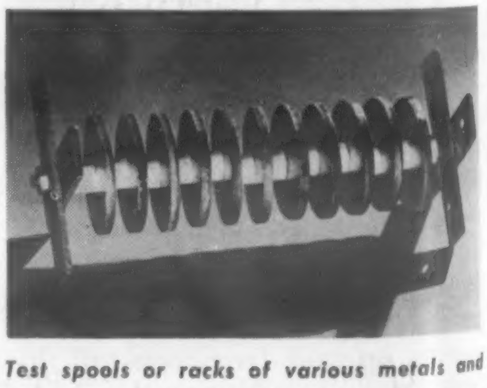
A quantity of information on the corrosive effects of various hot environments has been accumulated by the Development and Research Div. of The International Nickel Co., Inc., according to an announcement by T. H. Wickenden, vice president in charge of the Division. This has involved a continuous and expanding program designed to evaluate the corrosion resistance at high temperature of different metals and alloys for specific applications encountered in the aviation, petroleum, chemical processing, heat treating and other fields, especially those producing equipment and supplies for the defense program.

"There is still a great deal to be learned about high-temperature corrosion, not only with respect to some of the underlying principles governing surface reactions, but also from the practical aspect as to means of eliminating or minimizing corrosion damage by selection of appropriate alloys", Mr. Wickenden said. "As operating temperatures in many industries continue to increase, it is inevitable that high-temperature corrosion problems should multiply on a cumulative basis.

"Studies are being accelerated tremendously by the defense program, which involves not only military and naval equipment and supplies, but processes by which materials of all kinds are produced."

Mr. Wickenden pointed out that a large amount of data on the creep and rupture characteristics of materials at temperatures up to and including 1800 F and some data at temperatures as high as 2100 F, have been secured in the Company's Laboratories at Bayonne, N. J., and Huntington, West Va. In addition, test spools, or racks, have been installed under actual operating conditions in industry. Each of these spools contains specimens of a variety of alloys, and a comparison of their performance is made at frequent periods of time.

While strength characteristics are unquestionably important, he emphasized that to achieve long life and trouble-free service in high temperature environments, it is usually necessary to place governing importance on the corrosion behavior. This fact has been further confirmed by information on high-temperature corrosion mechanisms studied at the Bayonne and Huntington Laboratories and by engineers of the Development and Research Division. Information already secured has been made available to industry; additional data will be provided as developed.



Test spools or racks of various metals and alloys are being tested under actual operating conditions in high temperature industrial applications by the International Nickel Co.

Electrochemical Process Derusts Complete Machines without Disassembly

The British Trade Journal and Export World recently described a metal cleaning process that has been developed in Europe. The trade name of the process is Derustit. It does not attack sound metal in any way, and complete machines can often be derusted without disassembling. A demonstration was given in London recently at the works of Derustit Ltd., Grosvenor Road, S. W. 1. Numerous plants for operating the process have been established in England and in other foreign countries.

Derustit is the outcome of research initiated during the war with the object of salvaging machine tools and other valuable items damaged by water or exposure through enemy action. It employs a bath of alkali solution, through which a low-tension electric current is passed.

It has been found that Derustit can be safely applied to nearly all metals except certain magnesium and aluminum alloys, and when these are present in complete assemblies they can in most cases be fully protected by several alternative methods of masking or painting over with insulators. It should, however, be noted that although the process entirely removes rust, it does not prevent it from recurring; normal antirust precautions are necessary for treated articles.

The penetrating power is claimed to be such that even rusted-up typewriters, calculating machines and similar elaborate mechanisms can often be completely cleaned and freed of rust without removing a single nut, bolt or screw. Frequently the derusting alone has been found to be enough to restore machinery to full working order. Derustit does not affect dimensions. It removes all rust, corrosion and similar surface deposits from metal, but it does not remove a fraction of a thousandth of an inch of sound metal.

In the early stages of rust formation, although the layer of rust may look quite thick, only an almost infinitesimally thin surface layer of metal is actually oxidized. Derustit naturally cannot restore metal already corroded away, but as it removes absolutely no metal not already lost through rust, parts made to limits as fine as half a thousandth of an inch can be derusted—provided they are still in the early stages of rusting—and still remain within the makers' manufacturing tolerances. This is claimed to explain the success in treating such articles as micrometers, ball and roller bearings, machine tools, jigs and dies.

Radioactive Sources Assist in Studies of Industrial Applications of Radiation

The U. S. Atomic Energy Commission and the Brookhaven National Laboratory have announced that thousand-curie sources of gamma radiation will be made available to assist industrial organizations in studies of the applications of radiation to industrial process.

The thousand-curie sources, made of cobalt-60 or tantalum-182, each release as much gamma radiation as 2.2 lb of radium (an amount equal to the pre-World War II total world supply). Two such sources, one cobalt and the other tantalum, have been prepared in the Brookhaven National Laboratory nuclear reactor. Additional thousand-curie sources will be made as needed.

The sources were prepared as a part of a program organized by the AEC and university laboratories to determine the feasibility and safety of using radiation from by-products of nuclear reactors in killing bacteria, or initiating or accelerating chemical reactions. Industrial concerns now arrange with Brookhaven to have small samples of materials or products they wish to study exposed to radiation from the sources. Then, since materials so exposed do not themselves become radioactive, the samples can be easily returned to the sender for analysis and evaluation of the results of their irradiation.

Exposure to large quantities of radiation from atomic energy by-products—also obtainable from sources such as x-ray machines or electrostatic generators—is known to induce chemical changes in molecules. Under intense gamma radia-

(Continued on page 13)


THIS NEW MATERIAL
MAKES THESE PARTS
AND SAVES YOU $$$$
A rotor with three precious metal caps to act as contacts was needed by a leading automotive manufacturer for use in a special switch. Soldered-on caps were soft and expensive. Rivets might work loose.
As an ideal solution, this new Makepeace insert material was created. It consists of precious metal slugs brazed into strip stock and positioned to form the desired part. The precious contact material is only where it is wanted, firm and secure for blanking and forming. And . . . of great importance . . . it is hard and wear-resistant due to cold working
This new material is particularly adapted to rotors in switches and small bridge contacts . . . any formed part embodying two or more contact points. Please note . . . Patents have been applied for.
For better performance and lower unit cost, design your next switch to make use of this new material. Our own staff of thoroughly experienced engineers and metallurgists are at your service to assist in working out your particular problem.
Your inquiries are cordially invited and will receive our prompt and interested attention.
D. E. MAKEPEACE COMPANY
Laminated and Solid Precious Metals for Industrial Use • Fabricated Parts and Assemblies • Bar Contact Material • Precious Metal Solders
MAIN OFFICE AND PLANT, ATTLEBORO, MASSACHUSETTS
• NEW YORK OFFICE, 30 CHURCH STREET
CHICAGO OFFICE, 55 EAST WASHINGTON STREET

News Digest

tion bombardment some molecules break into parts and then recombine in a different way. Brookhaven scientists already have used radiation from a cobalt source to induce polymerization, or the building up of large molecules out of small ones. The result was a clear plastic, produced without the presence of heat, pressure and catalysts common in plastics manufacture.

As a second part of the program to develop industrial applications for radioactive by-products, Brookhaven is assisting universities holding related research contracts with the AEC. For example, Columbia University, New York City, is using radioactive sources in studying new methods of food preservation, and the possible toxicity of irradiated foods. At Massachusetts Institute of Technology, Cambridge, Mass., research workers are studying the amount of atomic bombardment necessary to kill bacteria and other organisms which commonly contaminate food products, and the effects of such radiation on food. Scientists at Yale University, New Haven, Conn., are exploring effects of intensive gamma radiation sources on chemical reactions of gases. Radioactivity probably has an effect on the rate of all chemical reactions, and such changes may be of importance in various industrial chemical processes. At the University of Michigan, Ann Arbor, Mich., a research group is studying effects of radiation on chemical and physical reactions.

In these university studies, thousand-curie sources produced by Brookhaven will provide the necessary intense gamma radiation. Further information on the availability of the Brookhaven irradiation service to industrial concerns can be obtained from the Director's Office, Brookhaven National Laboratory, Upton, N. Y.

Corrosion Resistance of Metallized Steel Studied

The American Welding Society's Committee on Metallizing has organized a test program to determine the corrosion resistance of steel having metallized coatings of zinc and

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Materials & Methods
SEPTEMBER 1951

Tin and Tungsten— Their Past, Present and Future

Tin and tungsten, high on the list of strategic materials, have little in common except their current scarcity and their vital importance in our economy.

by CHARLES A. SCARLOTT, Westinghouse Electric Corp.

● CERTAIN METALS, like some people, are continual storm centers. Tin is one. Tin has had a turbulent past, one marked with violent price fluctuations, periods of oversupply and undersupply, controlled buffer stocks, various plans of artificial price and production controls interlarded with periods of free trade. The immediate future promises to be no more quiet than the past. Recent months have seen tin the subject of rapid price gyrations, voluminous and heated debate in committee rooms, with many caustic allegations and counter allegations.

The reason for all this is not apparent. Everything that has happened to tin has happened to other metals and some nonmetallic raw materials—in some cases more so—without so much fuss resulting. Furthermore, the tonnage of tin produced is not great by comparison with other metals less frequently in the news and as essential to our economy. Compared to tin, the world produces 14 times as much copper, 10 times more zinc, nine times more lead, and eight times more aluminum. However, facts surrounding tin can be set forth to act as a backdrop for judgment.

Where Tin Comes From

The United States is the world's largest user of tin—from a third to a half—and produces almost none. Literally dozens of tin-bearing ores in the United States have been examined critically by the Bureau of Mines and the Geological Survey, but the answer always comes out the same—too low grade, production costs too high to be remotely competitive.

The capital of the tin-producing world is Malaya, which has been a consistent producer since 1891. Malaya contributes one-third of the world's total tin. In 1950 this was 57,500 tons (all tonnages given in long tons) out of a total of 167,400. The tin-bearing particles are recovered from sand by large dredges, by hydrosluicing, and, in a few cases, by conventional open-pit mining (see Fig 1).

World War II crippled the Malayan tin industry. Production had fallen from about 84,000 tons in 1940 to a low of 3100 tons in 1945. The Japanese occupation left the dredges ruined or in disrepair. But by a courageous and expensive rehabilitation program many dredges have been rebuilt, and new and much larger ones have been added, so that production is currently running close to the prewar average. However, at present there is the serious problem of banditry involving serious raids on mining activities, which not only discourages production in outlying districts but has brought exploration to a virtual halt.

In addition to Malaya, other countries of southeast Asia are major tin producers. Second after Malaya is Indonesia, which in the five-year period from 1937 through 1941 accounted for almost one-fifth of the world total. Others of the Asian group were Siam, 7.8; China, 5.3; Burma, 2.6; and Indo-China, 0.7%. Before the upset caused by war, Asia provided two-thirds of the world's total tin.

Many of the tin mines of the Far East suffered in major degree from the war. However, except in Burma, China and Indo-China, tin production has made a surprising comeback. By 1949 Asia was again contributing its prewar share of the world total. The political situation in several of these countries, notably China, however, makes the availability of their tin to the western world precarious.

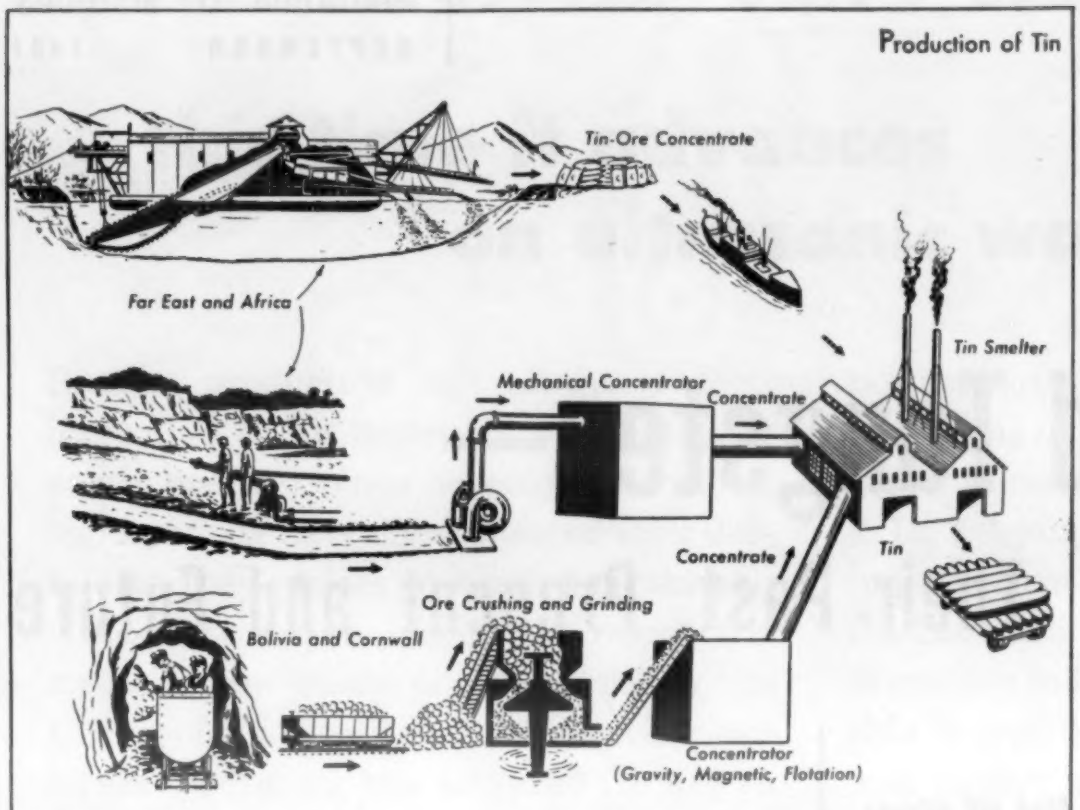

Fig 1—How tin is mined and produced.

Number three in tin-production is Bolivia, which has been turning out tin on a notable scale since 1887. In the late 30's it ran a pretty consistent 26,000 tons yearly, or 15% of the world output. Unlike placer mining in Malaya, Bolivian tin is mostly deep under ground. It runs in almost vertical veins of high quality in high mountains at altitudes of 12,000 to 17,000 ft, which makes physical exertion difficult, even for native Bolivians. In the Andes the ore is reached by tunnels bored almost horizontally into the mountains. Also unlike placer tin ore, in which the problem is the relatively simple one of separating tin particles from sand, the Bolivian cassiterite and other tin minerals are in hard rock. Also, the tin particles are associated with other minerals difficult to separate.

As a result, recovery of tin from Bolivian ore is poor. The range is from 35 to 85% cassiterite, with the average being barely half. Much of the loss comes in attempting to provide a high-grade concentrate by the several forms of gravity separation. There are some arguments that tin smelters in consuming countries should make it profitable for Bolivia to ship a lower grade concentrate to obtain more of the tin from the ore. Even as it is, the resulting concentrate shipped to the European and the one United States smelter is both poorer in grade (15 to 65% by comparison with about 72%) and more difficult to smelt than placer tin.

These factors, plus the difficulty of mining at such high altitudes and the desire of the Bolivian Government to raise the standard of living for its workers, make Bolivian tin more costly in the average. Another complicating factor is that during the last war, with Malayan tin cut off, Bolivia cooperated to bridge the gap and accelerated production. In doing so, the best ores were used, with detriment to the remaining deposits and a consequent reduction in eventual total recovery. Patino, Bolivia's largest tin mine, suffered a drop in grade from 2.31% before World War II to 1.50% in 1949.

Bolivia has only one small smelter. All the remainder is exported, about 45% to England and 55% to the U. S. Government smelter at Texas City, Tex. Here the combined low-grade Bolivian concentrates difficult to smelt are mixed with high-quality concentrates from Indonesia, Thailand and Belgian Congo, and reduced to metal.

Aside from the Far East and Bolivia the only sizable producers of tin are the Belgian Congo and Nigeria. In the five prewar years, together they turned out about one-tenth of the world total. Production in these two African countries rose during the war but has returned since to approximately the prewar levels. Nigeria's output is believed, however, to have passed its peak, which one year during the war reached 13,000 tons. Congo production touched a peak of 17,000 tons in 1945. The African mines resemble the surface operations of Asia. The U.S.S.R. claims now to be self-sufficient as to tin, although production of tin in the Soviet Union prior to World War II did not exceed a few thousand tons yearly.

Until 1860 Cornwall, England, was the largest provider of the world's tin, but in recent times, output has been running to about 1200 to 2000 tons of tin yearly or, roughly, 1% of the world total.

Small amounts of tin are produced in many other parts of the world. In 1950 thirteen nations mined between 100 and 1000 tons of tin each. Mexico sends a few hundred tons to the United States yearly. Canada produces about 200 tons. Australia and Argentina produce minor amounts, all used locally. These minor sums have amounted in recent years to about 4% of the world total.

How Much Is Left

Substantial figures as to world reserves of tin ore do not exist. In the Apr. 15, 1950 issue of *Mining World* Robert J. Nekervis, of the Tin Research Institute, gave a figure of world reserves of recoverable tin as 6 million long tons, or 38 years of 1949 rate of consumption. These are known deposits that can profitably be worked. Existing tin fields in Malaya have an expected life of about 20 years. It is safe to say that the world will not run out of tin for many decades.

The prospect for long life of Bolivian tin mines is, however, not good. The following statement was made by James Boyd, Director of the U. S. Bureau of Mines, before the Public Lands Committee of the House of Representatives on Aug. 8, 1950: "Proved ore reserves in Bolivia in 1945 were estimated at 340,000 tons, from which 200,000 to 210,00 tons of tin may be expected. These reserves represent a 5- to 6½-year supply (*i.e.,* at United States rate of use). Apparently the development of reserves is not keeping pace with exploitation either in grade of ore or of total tin content, indicating a future trend toward decreased output. Estimates giving inferred and possible reserves are not available." While tin production in Bolivia can be expected to continue for a number of years, high outputs should not be expected indefinitely.

Price of Tin

Tin production and price have long fluctuated widely. Attempts have been made to stabilize the industry by various types of artificial controls, such as cartels, establishment of buffer stocks, and intergovernment production-limitation agreements. Stability of the tin market was achieved by these methods in the period 1934 to 1940. Since the beginning of World War II production has been unrestricted, but price control was exercised in the principal consumer markets into late 1949. The United States Government imposed price controls during this period.

The price of tin has reflected the frequent dislocation of production and consumption, as the curve (Fig 2) shows. In the years ahead of World War I the price per pound varied modestly between 25 and 40¢. In World War I it rose to a peak of $1.10 per lb. In the months just ahead of hostilities in Korea the price of tin stood at about 75¢, but then the climb began, touching $1.83 last February.

This fantastic rise created a Congressional storm, with acrimonious charges of profiteering. A great deal of dust has been raised over the issue. While we do not pretend to offer a critical analysis of the matter, three facts seem pertinent: (a) Tin has been in free competition, a principle of trade espoused by this country. (b) The onset of heavy defense programs, not only in the United States, but elsewhere, sent the demand for tin skyrocketing. (c) Superimposed on this normal-plus-defense demand was the very heavy purchases by the United States Government for stockpile. It hardly seems surprising that all this had a large effect on price of a metal always sensitive to supply and demand ratios.

As a result, last March the United States announced it had stopped purchasing for stockpile and made the Reconstruction Finance Corp. the sole purchasing agent of tin and seller to industrial users in the United States. As a result, the price dropped to $1.42 per lb in May and stood in early June at $1.36.

What Tin Is Used For

About one-half the virgin tin used in the United States is for tin plate, this country being by all odds the largest user of "tin" cans in the world. Next in order of use in the prewar period (1937 to 1940) came: solder, 15; collapsible tubes and foil, 8; babbitt and bronze, about 6 each; and tinning, about 3½%. Miscellaneous uses made up the remaining 7%.

During the war needs rose sharply and strenuous efforts were made to reduce tin requirements. An intensive search was made for substitutes. Where none were found, the amount used for each purpose was decreased. These efforts were crowned with surprising success—especially in tin plate, where they have left a permanent mark on the pattern of tin use, as Fig 3 shows.

The biggest economy came in the way tin plate is made. Instead of dipping steel sheet in molten tin, the protective surface is applied electrolytically. As a consequence, the thickness of adhering tin is as much as desired. For many purposes the saving is two-thirds. Now about 62% of all tin plate in the United States is made this way. Although tin-plate production has now doubled, the amount of tin required is the same. In the four postwar years (1946 to 1949), out of an average total new tin consumption of 55,800 tons, 30,300 tons went to tin plate. The tin-plate proportion of the total new tin consumed remains about the same as before the war.

The war brought about other tin-conserving measures. Many are here to stay. These include the reduction of tin in solder and babbitts. Foil and tubes of aluminum have grown widely in use, capturing much of their market from tin. As a result the total United States' tin consumption in the first four postwar years stood about 10,000 tons less on the average than in the four prewar years. Only the amount used for solder has risen (from 9850 to 12,900 tons annually). The tonnage requirements for babbitt, bronze and tinning have remained substantially the same, but the amount used for foil and collapsible tubes has dropped from 5380 tons to only 880 tons yearly. The amount for miscellaneous uses has been cut in half.

Further tin-saving measures are in

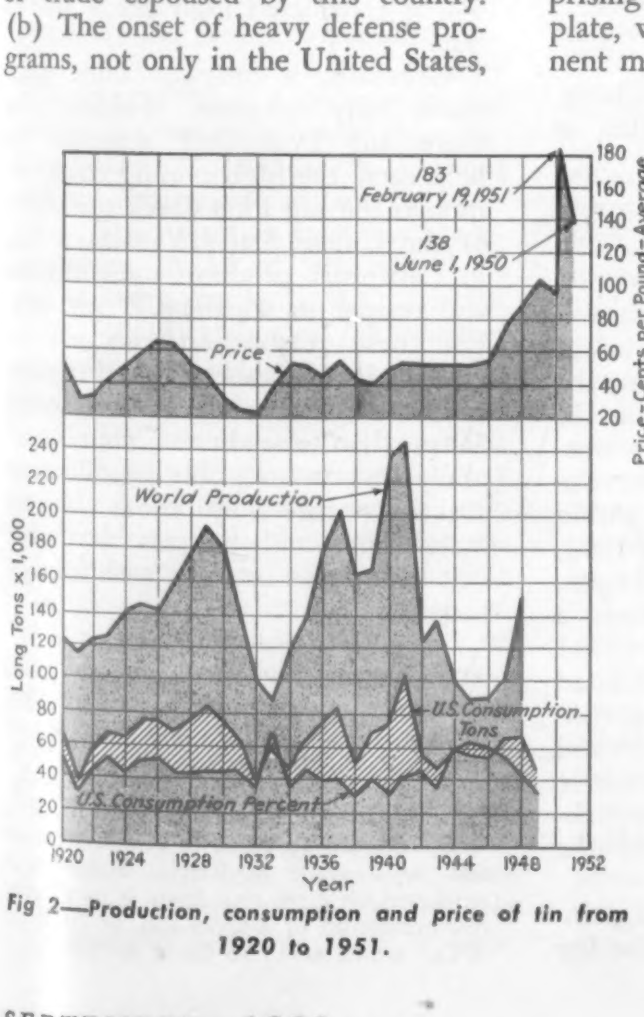

Fig 2—Production, consumption and price of tin from 1920 to 1951.

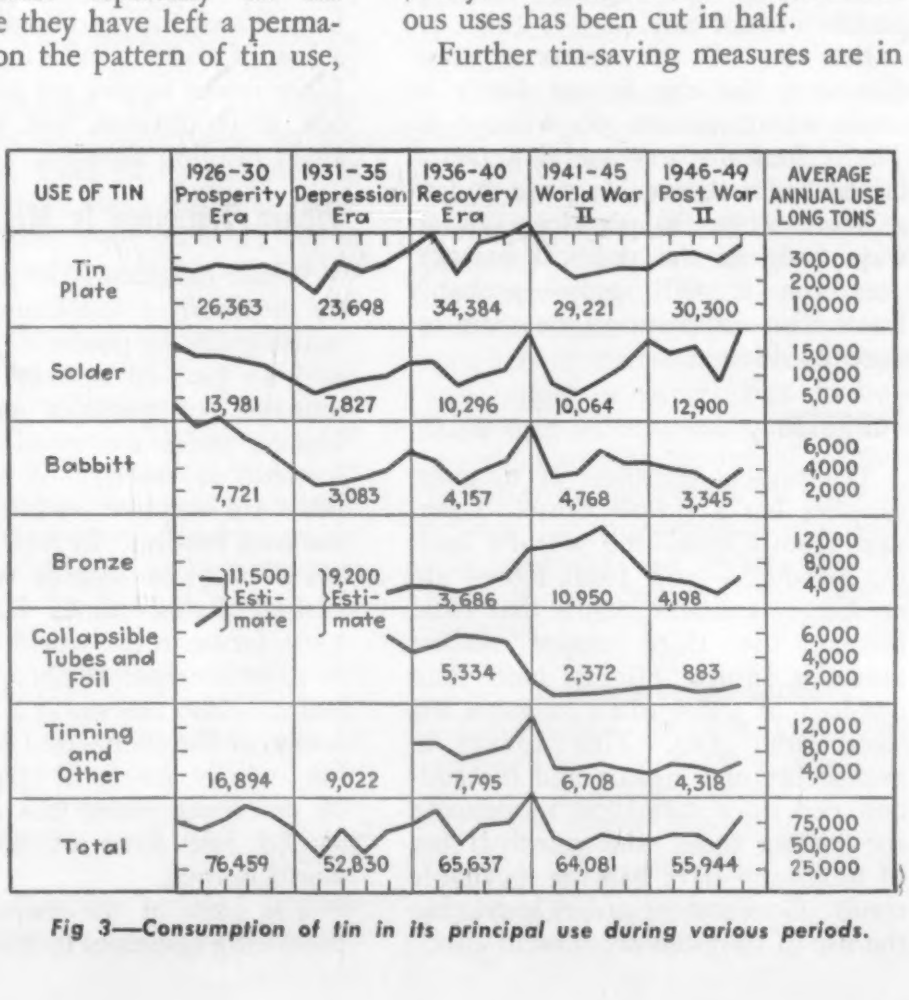

Fig 3—Consumption of tin in its principal use during various periods.

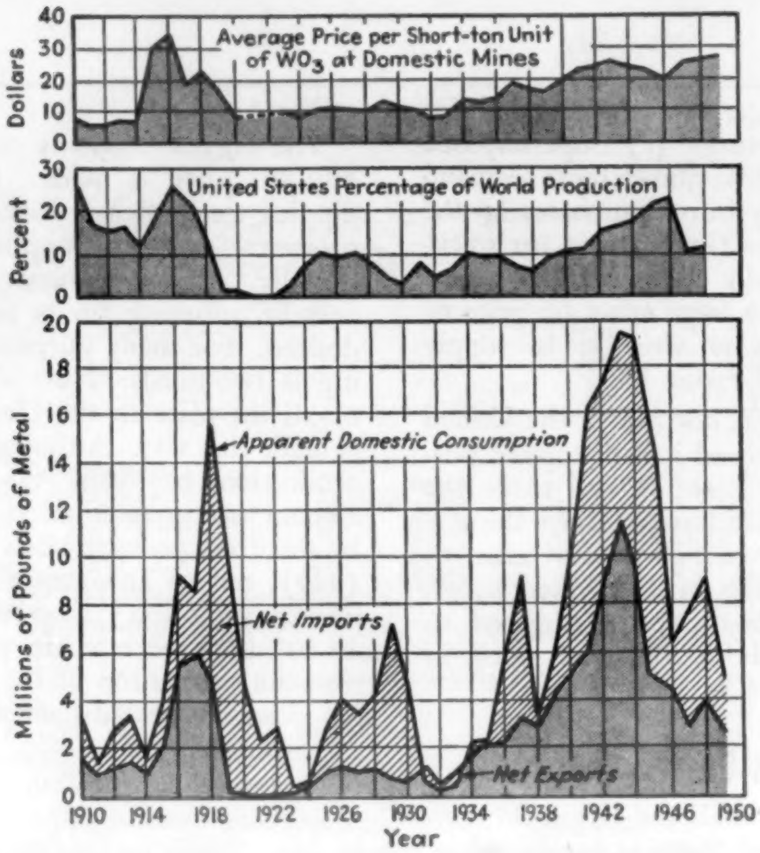

Fig 4—Production, consumption and price of tungsten from 1910 to 1950.

prospect. One proposal is to apply a thinner coat of tin on the side of the sheet to be used on the outside of the can than on the inside; but it poses some difficult problems for the tinplate industry, and only three tin mills are equipped or could be easily modified to accomplish it. There is always the possibility that someone may devise some other protective coating for steel—such as a synthetic—that would replace tin entirely for all or some cans. Several aggressive research programs with this as the objective are in progress. But the problem is not easy.

But, for all the tin-conservation measures, the day is not likely to come when we can do without it. Tin is basically too useful a metal. Given tin at reasonable price and in a world where supply does not always hang in the political balance, uses for it will grow—probably faster than conservation measures reduce its demand.

Tungsten

The present tightness of tungsten supplies has a simple cause. Tungsten from China—the world's leading producer—and from Korea are no longer available, while that from Burma, the third major Asiatic source is unsure. Slightly more than one-half of the world's tungsten has come from Asia. This decline in availability of tungsten and the sudden rise since mid-1950 in demand for cutting tools—the principal use of tungsten—have had the inevitable result. Government orders restricting the use of tungsten are now in effect.

Consumption of tungsten in the United States over the years has been extremely erratic. High peaks of consumption have been followed by sharp declines—a situation that has been exceedingly difficult for producers to cope with and one that does not encourage heavy mining investment. Use of tungsten in the five years ahead of World War II averaged about 6 million lb of metal annually. Consumption skyrocketed in the war to a peak of nearly 20 million lb in 1943, with an average of 17 million. The war over, use dropped immediately by two-thirds, reaching a low of about 5 million lb in 1949. More recent figures are not available, but it is obvious that tungsten is again heading skyward.

Where Tungsten Is Mined

While tungsten is in short supply, the position of the United States is nothing like so potentially precarious as with tin. In contrast to tin, the tonnages of tungsten used in the United States are small (only one-fortieth as much), of which two-fifths are supplied from mines within our own borders. In fact, since 1905, when tungsten records were begun, United States' mines have been a 13% factor in the world total (1945 to 1948 average: 16%). The United States is also the world's largest consumer of tungsten. In 1946, '47 and '48, which are fairly representative of peacetime years, this country absorbed just short of 30% of the world output.

The rank of the major tungsten-producing countries in 1948 (the last reasonably normal tungsten-producing year) stood as follows: China, 28; United States, 11; Portugal, 9; Bolivia, 8; Korea, 7; Burma, 5; Australia, 4; Brazil, 3%. Russia is supposed to be producing about 5% of the world's tungsten. Canada, Mexico, Peru, France, Spain, Sweden, the Congo, and Thailand have produced minor quantities, while trace amounts come from many other nations.

Most tungsten mines in the United States are in the Western states. California has been the principal producer the last two decades, and is currently providing about one-third of the total. Until lately, Nevada has been next with about one-fourth. Colorado in the last decade has provided only 4% of the national total. Idaho during World War II was a significant producer of tungsten, but since 1945 its production has declined to a low rate, as its principal mine was essentially exhausted during the war.

A newcomer is North Carolina. In 1941 the Tungsten Mining Co. began operations at a mine near the northern edge of North Carolina. Here is a large quantity of ore running about 25 lb of 60% tungsten-oxide concentrate.* Output has risen steadily until in 1949 it was 28% of the United States' total.

Tungsten ore in the United States occurs under ground in low concentrations, 0.5 to 3%. The grade is generally less than 1%. Ore running 3% is considered high grade and is rare.

Generally, a tungsten mine produces only tungsten. Seldom are there any by-product minerals to help carry the high mining costs, although the big Pine Creek operation of the United States Vanadium Co. in California produces molybdenum and copper in worthwhile amounts. For these reasons and because of much higher labor costs, tungsten costs more to produce in the United States than elsewhere. Thus, normally—when no political influences are at work—only those United States mines with the most favorable cost factors can compete with foreign tungsten.

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* Tungsten statistics are commonly given in terms of a concentrate containing 60% tungstic oxide (WO_3). For purposes of mathematics, however, one ton of 60% WO_3 concentrate contains 952 lb of tungsten. Thus, an ore running 25 lb of 60% WO_3 contains about 12 lb of tungsten per ton, or a grade of 0.6%. Tungsten is marketed on a per-unit basis, a unit being one-hundredth of a short ton, or 20 lb of WO_3, which is 15.86 lb of tungsten.

The United States, however, is not poor in tungsten reserves. The tungsten-ore deposits are large. How large is not known. Reserve figures are almost meaningless. Because mining of tungsten has not been a highly profitable operation and with almost no assurance of a succession of profitable years, the incentive for long-range exploration has been lacking. The United States could in a pinch become self-sufficient as to tungsten for many years to come. The price would become higher than industry is accustomed to pay, but probably not intolerably so.

Natural Forms of Tungsten

Tungsten is never found uncombined. There are at least a dozen chemical combinations, some extremely complex. Only four tungsten minerals are commercially important. One is scheelite or calcium tungstate ($CaWO_4$). The other three are combinations with iron and manganese, which run the complete scale of proportions. If the iron to manganese ratio exceeds four to one, the mineral is termed ferberite or iron tungstate ($FeWO_4$). On the other hand, if manganese predominates in about this ratio or more it is called Hubnerite or manganese tungstate ($MnWO_4$). All the intermediate proportions of iron and manganese—which comprise the greater part of the total—are called wolframite.

Because all four tungsten-bearing ores contain, at best, but 2 or 3% tungsten, the first problem is to provide a concentrate. This is done by crushing the ore to a fine powder and effecting a concentration of the tungsten-bearing particles by various gravity separations and/or by flotation. The object is to obtain a concentration of 55 to 70% (60% is the industry standard) WO_3 concentrate. The character of further processing, if any, depends upon the end use.

Most metals are isolated from their natural chemical partners before they are used. This is not true of tungsten. High-purity tungsten concentrates are used without further change as an alloying charge in steelmaking. In 1949 one-sixth of the tungsten consumed in the United States was used in this form. The form in which tungsten is most used—almost half in 1949—is ferro-tungsten, which is generally produced by charging tungsten ore together with coal, scrap and flux-forming materials in an electric knock-down furnace. Only a little over one-third of the tungsten used in this country ever passes through the metallic tungsten state, which is accomplished by a set of complex chemical processes.

Where Tungsten Goes

Prior to 1900 tungsten had almost no commercial use. Probably the first planned commercial use of tungsten as alloying agent in steel was Mushet's self-hardening tool steel (6 tungsten, 2% manganese) patented in 1868. Just before the turn of the century F. W. Taylor, of Bethlehem Steel Co., and Maunsel White discovered that tungsten steel is vastly superior for cutting metal at high speed.

In addition to cutting at higher speeds, tungsten-steel tools were found to be capable of taking heavier cuts. The resulting economies effected all over the world have been enormous. The new tungsten-steel tools have been a dominant factor in the era of mass production of machine-tool products. Prominent among these tungsten-steel tools is the so-called 18-4-1 high-speed steel whose composition is: tungsten, 18; chromium, 4; and vanadium, 1%. The percentage of vanadium may vary up to 3% with or without the addition of cobalt.

Nearly all steels containing tungsten are now made in the electric furnace. (The melting point of tungsten is far too high for a melt to be achieved in blast or open-hearth steelmaking furnaces.) Tungsten steels were once produced mostly by the crucible process, which required tungsten powder of 95 to 98% purity. The electric furnace, on the other hand, takes in its tungsten as ferro-tungsten. Ferro-tungsten melts between 3500 and 3700 F, while tungsten powder melts between 6000 and 6200 F. Neither, of course, will actually melt in a steelmaking furnace, but the ferro-alloy can be more easily dissolved because of its lower fusion temperature. The lower specific gravity of ferro-tungsten and its more favorable size, also, as compared with tungsten powder, results in a slower rate of settling through the bath to the bottom and thus a quicker solution.

High-speed cutting steels take more of the tungsten stocks than any other use. Other important uses of tungsten-alloyed steels are for hot-work dies, low-alloy tool steels, permanent magnets, and heat resisting steels.

Of the tungsten reduced to metallic form, some is used for cemented carbides. High-purity tungsten powder is combined with carbon at high temperature in an inert atmosphere. The resulting carbide is crushed to a powder, mixed with cobalt powder that acts as the cementing agent when the product is sintered. The result is a cemented tungsten carbide, which approaches the diamond for hardness. Cemented carbides are used for rock drills, dies, and many types of cutting tools, such as single-point tools, form tools, milling cutters, etc. These are indispensable to today's low-cost industrial processes.

While the tonnage use of tungsten as filament wire in incandescent lamps is small—1 or 2% of the annual total—it is indispensable. There is no known substitute for drawn tungsten wire in electric lamps. Nor is there likely to be. The energy-to-light conversion efficiency of an incandescent solid increases rapidly with temperature. And tungsten can be operated hotter without softening than any other substance except carbon, because its melting point—about 6150 F—is the highest of all metals. But a small amount of tungsten makes a lot of lamp filaments. A pound of tungsten drawn into a wire 6.2 miles long, and 0.0022 in. in dia provides filaments for 14,400 lamps of 60-watt size.

Tungsten, for all its high-temperature qualities cannot be used for turbine blading. At steam- and gas-turbine temperatures it forms a non-protective oxide that soon leads to failure. Also, its high density makes it undesirable for high rotating speeds.

Other important uses of metallic tungsten in the electric industry is as lead-in wires for electric lamps (tungsten and soft glass have nearly the same coefficient of thermal expansion) and for certain elements in electronic tubes. Electrical contacts and electrodes are made of sintered tungsten or tungsten carbide powder and copper or silver. But, in bulk, these uses of tungsten metal are far overshadowed by the use of tungsten for alloying with steel. It does not appear that this aspect of our industrial economy will in the long run have to be curtailed for lack of tungsten.

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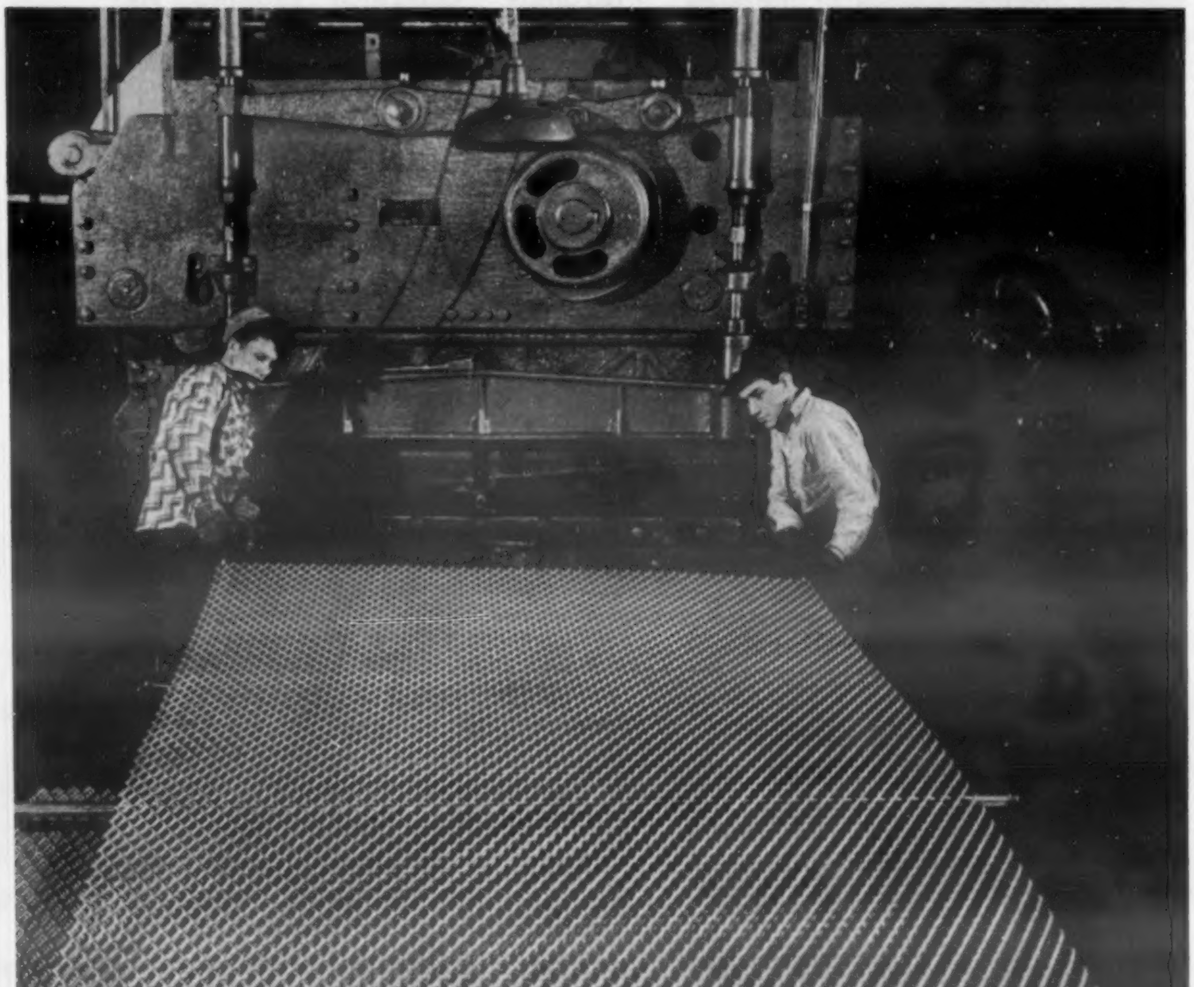
Expanded Metals Save Weight and Material

by **PHILIP O'KEEFE, Associate Editor, Materials & Methods**



Sixteen-ft-long expanded metal panels of heavy gage are cut into 8-ft lengths in this power shear. Because expanded metal sheets are all one piece and precision cut, they keep their shape, have no loose ends, and can be handled like solid sheet. (All photos courtesy of Wheeling Corrugating Co.)

The engineering applications of expanded metal are increasing as its economies and fabricating properties become generally appreciated.

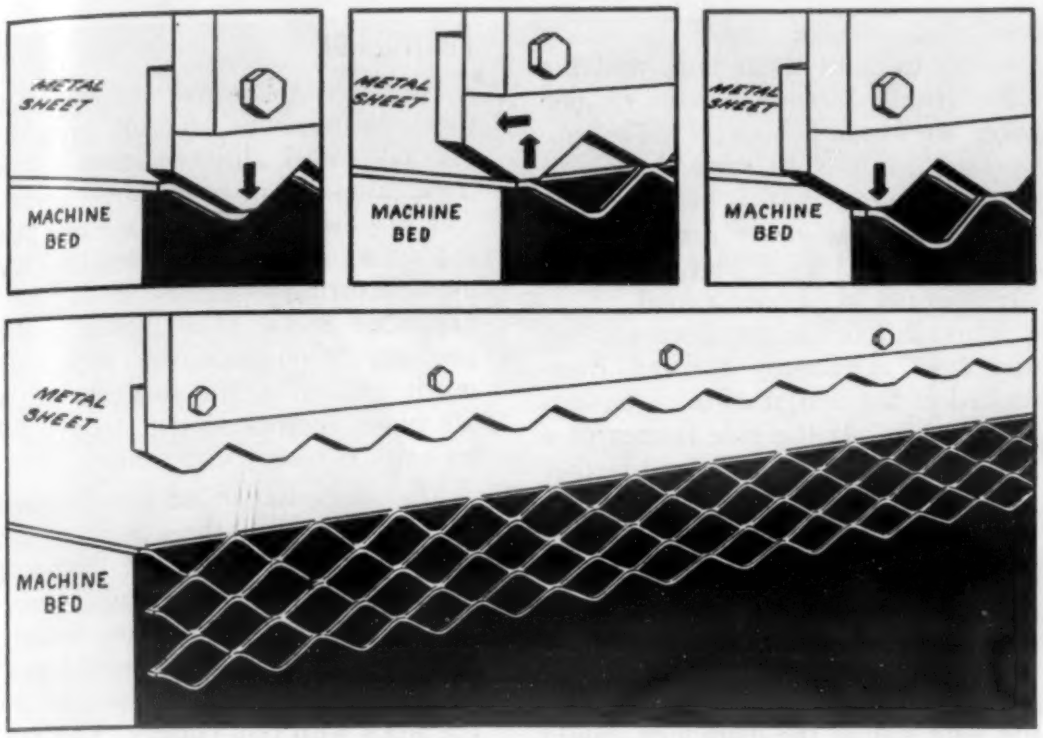
● EXPANDED METAL IS MADE from solid sheet that is slit and stretched to form a one-piece sheet with uniform diamond openings. No metal is removed during the operation and the expanded metal may cover ten times the area of the solid sheet from which it is made. The actual expansion obtained in the finished product depends upon the gage and diamond size.

Since the finished sheet of expanded metal is all one piece, it cannot ravel or fray. Each sheet is made up of a continuous pattern of unbroken metal without interlacing, tying, soldering or welding. This gives a high strength-to-weight ratio, dimensional stability and rigidity, and also makes the material easy to handle and fabricate.

The thickness of the metal and the size of the expanded diamonds depend on the application for which the material is intended. Structural uses of expanded metal in catwalks, floor gratings, and concrete reinforcement, and industrial applications in machine and drive guards are generally recognized, but the more recent designs of expanded metal parts in consumer goods are perhaps not as fully appreciated.

In the process of manufacturing expanded metal, the bridges between the diamonds are turned at an angle to the plane of the sheet and additional lateral stability is imparted that could not be achieved with an equal weight of standard sheet. For products in which surface smoothness is more important than compressive strength, the webs can be flattened by cold-rolling after fabrication.

Under present conditions, the savings in weight and metal for a given strength or area coverage with



In the manufacture of expanded metal, a solid sheet of metal is fed over the edge of a machine bed. A serrated knife blade cuts a thin strip from the edge of the sheet. The knife then moves up again and slides to the left, half the length of a diamond, while the sheet is advanced on the bed. The knife descends for another bite, retracts, and then moves back to the right to repeat the process.

this material are particularly attractive. Other valuable properties include the ventilation possible through the open diamonds and the accessibility and visability allowed for working parts through machine guards and walkways.

Available Materials

Expanded metal can be made from hot- or cold-rolled steel, stainless steel, aluminum, copper, brass, nickel, Inconel and monel. Steel can be given a variety of finishes—plain, lacquered, galvanized, painted or phosphate coated.

In steel, the sheets expanded range from 20 gage to 3/8 in. in thickness, and standard diamond sizes cover 1/4 to 6 in. in width. The diamond width designation is the nominal value of the shorter dimension across the opening, from center to center on the bridge. The sizes that are commercially available in carbon steel include 1/4-, 1/2-, 3/4-, 1-, 1 1/2-, 3- and 6-in. diamonds, with the sheet metal gage from which the expanded metal is made increasing with the size of the diamonds. In material intended for concrete reinforcing and floor loading the steel gages tend to be heavier than standard products.

Stainless steel expanded metal is supplied in 1/2-, 3/4- and 1 1/2-in. diamond sizes, from 10-, 13-, 16- and 18-gage sheet. Stainless floor grating is somewhat heavier. Aluminum comes regularly with 1/2-, 3/4- and 1 1/2-in. openings, made from 8, 12 and 16 B & S gages. Monel expanded metal is produced in all gages from 22 to 10, and Inconel gages vary from 22 to 13. Mesh sizes run from 1/4 to 1 1/2 in. for monel and 1/2 to 1 1/2 in. for Inconel.

Expanded copper, nickel, Inconel and monel must be ordered special, but the sizes in general conform to those available in the standard metals. Expanded metal can be furnished in the as-cut condition, with the burrs removed, or cold-rolled to flatten the webs.

Different knives are required for different sizes of diamonds, although many different weights or thicknesses of the same mesh style can be cut with the same knife. Within certain limits, a slight variation, making the diamonds narrower than standard, can be accomplished; but since wider diamonds increase the strain in the metal and shorten the bridges because of the deeper cuts, each variation of this nature should be investigated with the manufacturer.

Since the knives are made from special tool steel and are expensive, manufacture of special expanded metal for small orders is not feasible. Delivery even on large volume special orders is delayed because making and heat treating the required knives takes time.

Design Characteristics

The first point to be considered in designing an expanded metal product is the size of the openings. As a basic rule of economy, the largest diamonds that can be used should be chosen. For ordinary applications, either strength or stiffness are the guiding criterions, and the larger the diamond, the greater the strength and stiffness for the same weight per sq ft. This is apparent when it is considered that four steel strips 1/4 in. wide by 1/16 in. thick will not carry as much load with the same deflection as one strip 1/4 in. wide by 1/4 in. thick. With expanded metal, the fewer the strands, the larger and stronger they are for the same weight.

Other design considerations are obvious to the experienced engineer. The size of the diamond should be in proportion to the size of the panel, and the long way of the diamonds should follow the outline. The size of the diamond must also be chosen smaller than any objects that are to be excluded or contained. Regular

On outdoor machinery and ladder guards, expanded metal resists corrosion well, since there are no pockets between the strands to accelerate attack.

expanded metal can be used for machine guards, but leather belts must have flattened metal guards to avoid cutting in case of whip or breakage. Flattened mesh, on the other hand, is not as efficient on air vent grills, since the percentage of openings is greater with regular expanded metal, and the turbulence set up is lower.

The choice between a heavy mesh with a light frame and a light mesh with a heavy frame will vary with conditions. When the length of a panel or the loading on it is to be increased, it will always cost more to give the necessary extra strength by adding a frame to the original mesh than it would to go to a heavier, unframed mesh. However, if it is necessary to use an edging for appearance, or some other reasons, the strength should be built into the edging and a lighter mesh used.

When a frame is used, the deflection of the mesh will often depend more upon the frame construction than on the size of the expanded metal itself. The strings in a tennis racquet will support a considerable load because the frame is strong enough to hold them taut, and the same principle applies to a framed piece of expanded metal. The important thing is to keep the frame strong enough in the plane of the mesh as well as in the vertical, load-carrying direction, so that the assembly does not sag under a load.

This differentiation between sag and true deflection is often overlooked in the design of trays, baskets and shelves. If the side frames of a tray 12 in. wide are sprung together 1/8 in., the resulting sag is 3/4 in. at the center of the tray. The heavier the mesh, of course, the less it will deflect and the less it will pull in the sides and, consequently, the lighter the frame required.

In designing a rectangular tray, the long way of the diamonds should run the short way of the tray in order to reduce the deflection. If weight is a factor, a much lighter frame can be used when one or more flat bar spreaders reinforce the frame sides against deflection. These spreaders should run parallel to the short way of the diamonds.

Fabrication

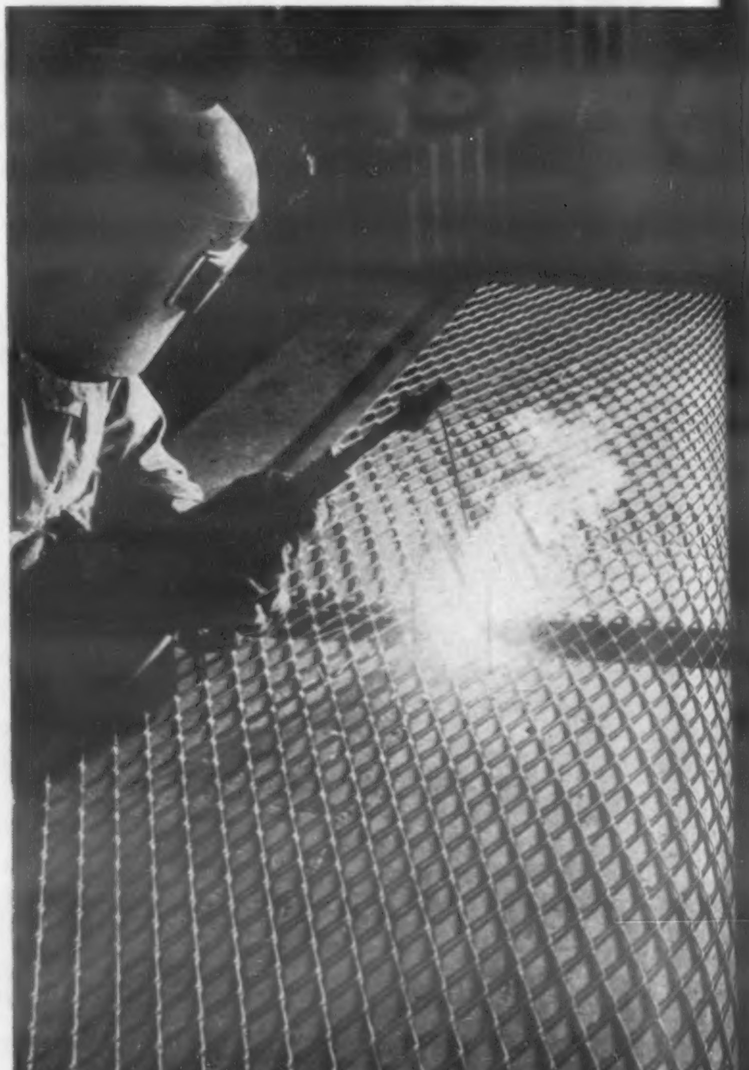
Although the same equipment is used, the methods of fabricating expanded metal differ slightly from those used on ordinary sheet metal. The big difference is the stresses that are set up in expanded metal by the manufacturing processes. In flattened expanded metal those stresses, not uniform throughout the sheet, are much greater in the bridges, which are twice as thick as the strands and take much more distortion.

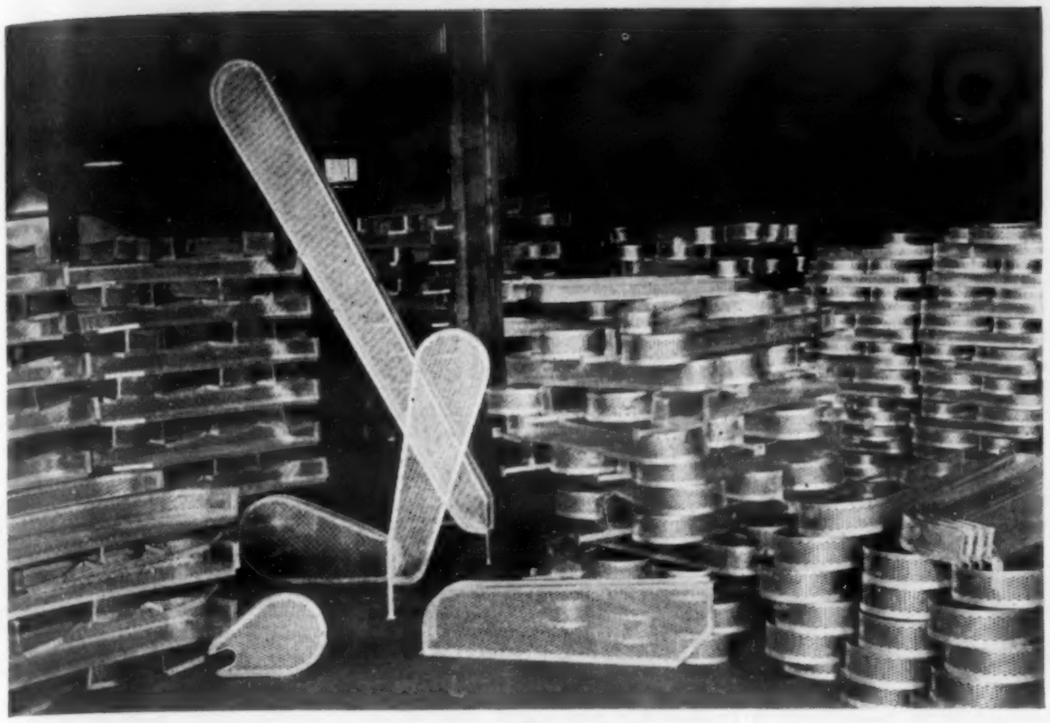
Shearing—Expanded metal cannot be sheared along the center of the bridges lengthwise of the diamonds in one operation. The usual procedure is to shear through the strands, about one quarter of a diamond away from the bridge, and then trim off the stubs with bolt cutters. This procedure is not difficult on 9-gage or lighter metal.

Heavier gages can be split down the bridges by an acetylene cutting torch with a very fine cutting tip. This procedure cannot be used with light material since the torch burns through and gives a rough job.

Fabricating expanded metal requires the same kind of machinery and tools used to work regular steel sheet. Here, heavy gage, unflattened expanded metal is being bent at more than a right angle.

To make standard 4- by 8-ft panels for industrial plant storerooms and enclosures, pre-cut expanded metal is arc-welded to sturdy angle iron frames.





Expanded metal is used in many machine guards and industrial enclosures. It is lighter than solid sheet of equal strength, allows working parts to be seen, air to circulate.

Shearing crosswise of the diamonds can be done at any point on expanded metal with a power shear. If a power shear with good hold-downs and back-gages is used, flattened expanded metal can be cut to $\pm 1/16$-in. tolerances, and with special care, $\pm 1/32$-in. is possible. Shearing expanded metal that has not been flattened is more difficult, since the sloped strands can deflect the blade no matter how closely the gages might be set. The closest tolerance that can be expected on regular mesh is 1/16 in., although this will grow to 1/8 in. at times.

The additional care taken to line the diamonds up in adjacent panels and keep the slope of the diamonds the same makes for a much neater and more workmanlike job.

Torch Cutting—Hand cutting is preferred to the use of mechanical burners. The automatic machines, traveling at constant speed, cannot preheat the individual strands the way the material ahead of the cutting flame in solid sheet is heated by conduction, and a slight pause is required before each strand in expanded metal.

Punching and Drilling—Expanded metal should be punched and drilled through a metal template rigidly fastened to the sheet; the strands tend to throw an unsupported drill or punch off center. The largest possible hole in any case should be specified to avoid breakage on drills and tools.

Forming—Expanded metal can be formed in a power brake with no difficulty. Care should be used to avoid catching the diamonds on the female die, however, especially with unflattened metal. Rounding the die corners helps, although if the gage is light and the quantity not too great, it is better to make bends on a hand brake.

Bends should be arranged to occur between the bridges, since the critical point in expanded metal is where the strand joins the bridges, and a bend at this point may cause a break unless a radius of at least 1/8 in. is allowed for 9-gage or thinner mesh. A radius equal to or greater than the strand width should be used with heavier gages.

Spinning and drawing expanded metal are limited by the amount of forming the metal can take after the severe cold-working in the fabrication expanding process. The appearance of the mesh is also affected by the uneven change in the size and shape of the diamonds. The metal is usually normalized or annealed if any extensive forming of this kind is to be attempted.

Welding—Arc welding presents no special problems but requires care. The size of the electrode should be in proportion to the size of the strand. Usually from 3/32- to 5/32-in. wire is best, although up to 3/16-in. electrodes are used on heavier gages.

Arc welding light mesh requires an experienced welder with a light touch. The narrow strands cannot dispel the heat as a solid sheet can, and burning can result.

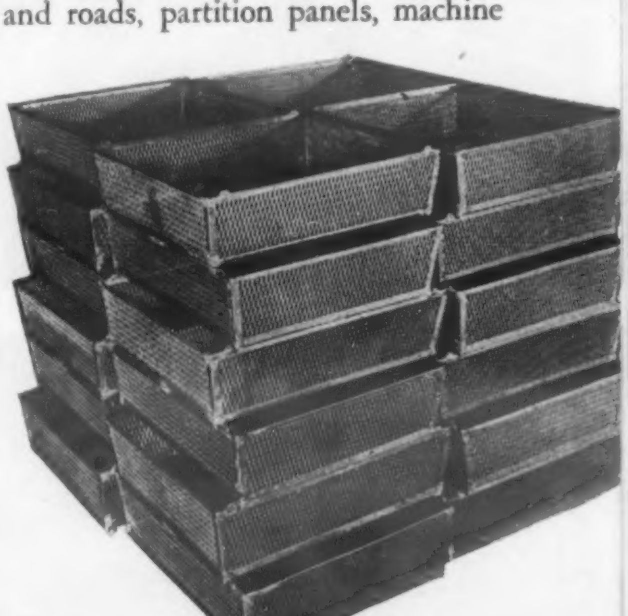
Little warpage occurs in welding mesh. Its spring construction localizes the expansion effect, and it returns to normal after cooling. Welding mesh to solid frames might cause buckling, however, unless periodic tacking is used.

Gas and fusion welding are done on expanded metal in about the same way as on solid sheet. The appearance of the weld is good in both cases, but warping is greater than with arc welding due to the longer heating time used with the gas process.

Expanded metal can be spot-welded without excessive warpage if the welds are staggered correctly. Automatic welders are not too well adapted to expanded metal, though, and a foot-controlled machine is better able to hit the mesh efficiently.

New Uses

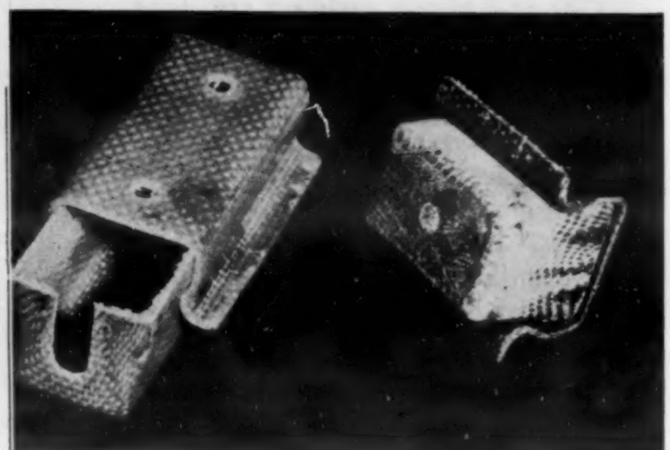
Expanded metal is now being used for concrete reinforcing for buildings and roads, partition panels, machine and conveyor guards, metal furniture, catwalks and safety floor gratings. In its smallest size, known as metal lath, it is used as a wall and ceiling plaster base.

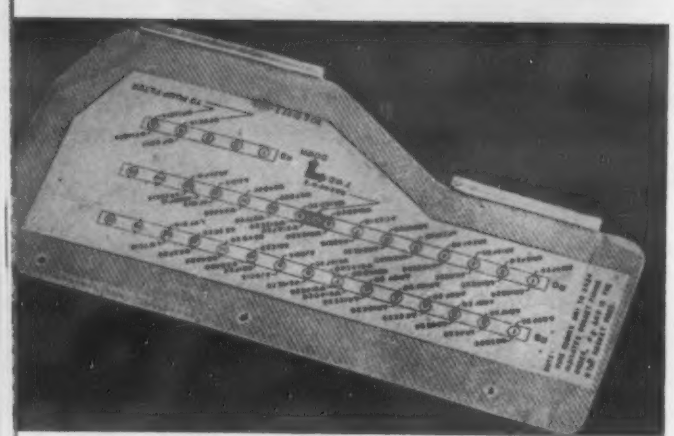


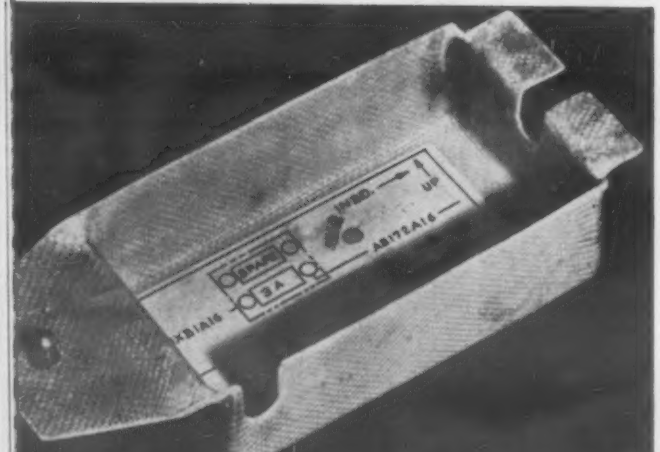
Baskets and trays are one of the most important applications of expanded metal, which cuts the weight and allows the contents to drain.

Aluminum expanded metal is even lighter than steel, and is being used in furniture, consumer goods, building and chemical industrial plants.

Monel, Inconel, nickel and stainless steel expanded metals find application for the most part in baskets and machine guards that are exposed to corrosive atmospheres or solutions. This field is growing because of the weight and material savings possible.







Production parts molded of plastic impregnated glass fiber are used for a variety of parts in the Republic Thunderjet where high dimensional accuracy is not necessary. These parts do not require expensive dies to mold and have excellent dielectric properties for electronic equipment boxes and covers.

Low-Pressure Molded Glass Fiber Parts Economical in Small Runs

Polyester styrene impregnated glass fiber moldings made at relatively low pressures and temperatures can now be used for many parts that are uneconomical to produce by conventional methods.

by CHRIS D. BIRMINGHAM, Plastics Engineer, Republic Aviation Corp.

● GLASS FIBER MOLDINGS with polyester styrene binder are now being used for many parts that have never been considered practical to mold in plastics before. These molded parts are tough and strong and take considerable flexure without damage. They are light in weight and have good dielectric properties.

The key to the new molded glass fiber applications is the low-pressure molding process that is used. Until now, few metal products manufacturers could afford to install the conventional plastics molding equipment to make parts needed only in small quantities. Commercial plastics molders have also been reluctant to take small production jobs because the high price of the dies used in conventional plastics molding kept unit part cost high on short runs. For these reasons, many parts that could have been molded were actually never made in this form.

This balance is changing, however. Molded glass fiber parts with a polyester styrene binder are processed at relatively low temperatures and pressures, and can be made in cheap dies. The cheaper dies that are used make these molded parts practical for many applications.

Materials

Two different types of glass fiber are used in this work. One is a flexible woven glass cloth known as No. 164 (Owens-Corning). This cloth is woven with warp and woof just as other fabrics are. The second material, glass fiber mat, is made from short fibers of glass, arranged in random fashion, with no specific pattern. The fibers of the mat are held together by a binder which softens and flows when it is subjected to heat and pressure.

The mat is not as strong in itself as the woven fabric. It is cheaper, however, and the strength and other properties of a molding made from the mat are almost equal to the properties of a similar molding containing an equivalent amount of fiber in the woven form. Either form can be used in making many parts.

In both cases, the strength of the part is imparted by the glass fibers; the resin acts mainly as a binder. To make the molding strong, these fibers must overlap and must pass around corners and fillets where the walls of the molding meet.

The polyester styrene plastic binder is applied to the glass fiber in liquid

Resin impregnated laminations of glass fiber fabric are put into a heated mold in a hydraulic press. The mold shapes the part and the heat cures the resin. The flash around the edge is cut off in a subsequent operation.

form. In some cases this liquid is merely dumped into the mold which forms the glass fiber. It can also be applied by brushing or dipping the glass fiber, usually before the glass reinforcement is put in the mold.

Layup Moldings

For parts that are large, complex, fairly deep, or with corners of relatively small radius, the glass fabric is cut to shape and laid in the mold by hand, layer by layer. Liquid resin is then impregnated into the fabric. The pieces may cover the whole mold surfaces or may be in strips arranged to lie without wrinkles in the mold. The strips of the material are overlapped and the cut edges in one layer are covered with continuous fabric in the next layer. The finished molding will not be of uniform thickness, being thicker where the edge laps are made. For many applications this is not significant, however.

Sometimes a dummy mold is used to layup the fabric. One part is being laid out in the dummy while the preceding one is being formed and cured in the real mold. This shortens the production cycle time, since the mold never gets a chance to cool very much.

Hand layup is slow, but it can be done by relatively inexperienced labor. Actually, the labor is offset (for the small quantities produced) by the low mold cost. The molds are cheap because the curing pressure needed is low. The molds can be improvised from plate or stock, and cost only a small fraction of the prices paid for hardened steel molds used to form other plastics from powder and preforms.

Draw Molding

Either mats or woven fabric can be used in draw molding. The mats or fabric, usually in three or more layers, are cut to a particular shape or are used in squares or rectangles. The glass fiber is placed on top of the bottom half of a mold and is drawn down into the mold when the upper half is lowered and pressed into place. It is not necessary to layup the material in the mold before it is closed. The important thing is that the mats or fabric must draw down into the cavity without tearing or wrinkling very much. For this reason this process is limited to small, simple parts that do not require a deep draw and have generously filleted corners.

The laminations are usually put into the mold dry, and the liquid

Removing a glass fiber molding from the mold in which it has been cured. The cut strips of glass fabric are pasted up in the dummy mold at the right and transferred to the mold for curing.

resin is poured in before the press is closed. As pressure is applied, the liquid fills the voids between the fibers. One reason for using low pressures is to avoid forcing the liquid out of the mold.

The molding can be done in any press that can be closed slowly and exerts the necessary moderate pressure. The Republic Aviation Corp. even uses hand operated arbor presses for some small moldings. Low cost air presses are preferred for most parts, however.

Bag Molding

Good results are also obtained with bag molding in which no male force is employed in the molding process. A bag or a blanket of flexible material that makes an air tight enclosure around the part is often used to exert enough force to hold the laminates together. The bag or blanket is sealed to itself or to a metal backing and the air is exhausted so that the enclosure presses tightly against the impregnated laminates.

The bags or blankets that are employed are often made from 0.002-in films of polyvinyl alcohol. These films are strong enough and stretch to fit irregular contours. The edges of the film are joined or clamped with rubber gaskets to a plate, the air is exhausted, and the mold is placed in an oven to cure the impregnating resin.

This method is used to make parts that are too large for a press or are shaped so that a press would not be feasible or would necessitate too high a mold cost.

The nose wheel splash guard for the Thunderbolt is molded from glass fiber mat in a hydraulic press. The lower mold is Kirksite. It rests on a heated plate which raises the temperature for curing. The upper mold is Neoprene to prevent the escape of liquid resin.

Applications

All moldings made by these methods have rough, unfinished edges, corresponding to the flash on conventional moldings made in flash molds. These edges are usually cut off with a band saw and the edges are sanded or filed smooth. Fastening holes can be drilled and even tapped. The tools used are the same as those required for metal, but they wear more rapidly due to the abrasive action of the glass fibers.

The accompanying illustrations show typical moldings. Some of these are fixtures, while others are production parts. Some 225 different parts used in Thunderjet airplanes are now being molded by Republic. None of these are structural parts, in the sense that they take loads as components of airframes.

Many serve as panels or boxes in electronic circuits. These moldings are strong and light, and while they are somewhat flexible, they are rigid enough to hold their shapes in these applications. The excellent dielectric properties of the moldings do not change significantly with moisture exposure because both the plastic and the glass are non-hygroscopic.

Production parts, being thin and flexible, are not usually held to close dimensional tolerances since they are not used where close fits are needed. Moldings used as fixtures have relatively thick walls and can be held within close dimensional limits. These fixtures can also be made in irregular shapes with whatever curvature variations are required.

Glass fiber moldings to be used for fixtures are made by laying up laminations and impregnating them before curing. Production parts usually have thinner sections than these fixtures.

How to Determine Toughness of Steels from Notched Bar Tests

by E. J. RIPLING, Senior Research Associate,
Dept. of Metallurgical Engineering, Case Institute of Technology

Charts showing notched properties as a function of tensile strength can be used to indicate safe and unsafe strength levels, and make it possible to compare the toughness properties of steels at the same hardness.

● METAL PARTS WHICH are not subjected to wear or alternating stresses fail mechanically in one of two ways. They may either deform to such an extent that they are no longer useful, or they may fail in a more catastrophic fashion by fracturing. The resistance of a part to failure by deformation is dependent on its yield and tensile strength properties, so that failures of this type are readily eliminated in steel by increasing the strength levels by heat treatment. There is a limit to this allowable increase in strength level, however, since the tendency for sudden failure by fracture depends mainly on the ductility (or toughness) of the metal, and this property decreases with increasing strength level.

For this reason, the notched property of a steel (an index of its ability to resist fracturing) is frequently plotted as a function of the steel's strength level (an index of its ability to resist deformation). Plots of this type are made for heat treated steels by finding the tensile strength as a function of the tempering temperature and the notched properties as a function of tempering temperature. The notched properties can then be represented as a function of the tensile strength. Charts of this type make it quite easy to separate safe and unsafe strength levels, and make it possible to compare the notched (toughness) properties of various steels at the same hardness.

Typical Curves

When either the static notched tensile properties of heat treated steels or their (Charpy) notched impact toughness are plotted as functions of the strength level, they show curves of the type shown in Fig 1. It should be noted, however, that most data available on heat treated steels do not show the peak at very high strength levels since this section of the notch strength-tensile strength curve is usually not thoroughly investigated.

For a particular steel, the minimum (labeled B) and the high strength level maximum (labeled C) appear at the same strength level in both the static and impact tests. This minimum corresponds to the 500 to 600 F tempering ductility minimum while the peak C corresponds to the notched ductiliy maximum obtained with steels tempered around 400 F.

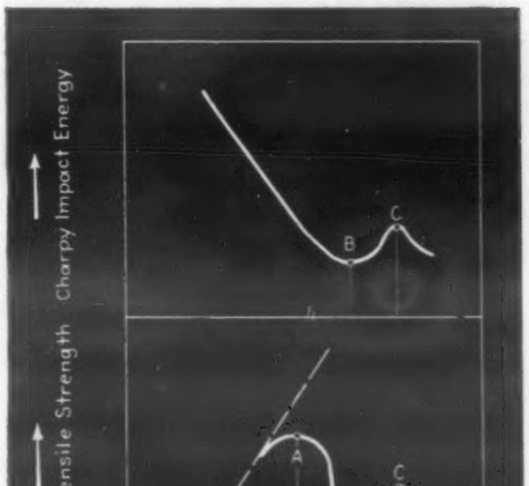


Fig 1—The Charpy impact and the static notched properties show a standard pattern when plotted against the strength level of any steel.

The notch strength-tensile strength

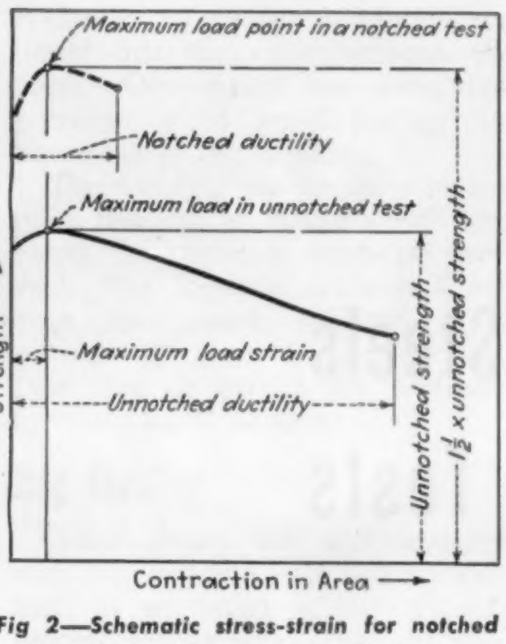


Fig 2—Schematic stress-strain for notched and unnotched tensile tests of the same steel show that the maximum load point occurs at the same contraction in area for both pieces, but the notched piece takes 1.5 times as much stress.

curve also shows a maximum at a lower strength level, labeled A in Fig 1, which does not appear in the impact curve. This maximum has been used to separate safe and unsafe mechanical behaviors. At strength levels less than that at which this peak occurs, the steel is considered to possess sufficient ductility and toughness to withstand severe stress conditions, while at higher strength levels the ability to withstand notch effects drops off very rapidly with increasing strength level and the steel is considered unsafe.

Although all the steels on which data are available show notch property vs. strength level curves of the type shown in Fig 1, the position and shape of the minimum and maximum parts of the curve vary enormously from steel to steel. Consequently, the maximum stress allowable under severe service conditions will also vary greatly for the available steels. Those which exhibit a broad maximum at (A) and a shallow minimum at (B) are the safest at tensile strengths exceeding, say, 200,000 psi.

Stress-Strain Behavior

The shape of the notched strength-tensile strength curve in Fig 1 can be explained on the basis of the stress-strain behaviors of notched and unnotched test bars.

Such an explanation is helpful in analyzing notch behaviors since certain of these behaviors seem inconsistent. For example, the toughness and ductility minimum (B) and the high strength level maximum (C) in Fig 1 are found at the same strength level in both the notch strength and toughness (or ductility) properties, although in general, strength and ductility vary in opposite directions. At low strength levels, on the other hand, in keeping with the general relationship between strength and ductility, the notch strength increases with increasing strength levels, while the toughness decreases. In this range of low strength levels, the relationship between notch strength and tensile strength is such that the notch strength always equals one and one-half times the tensile strength. Another seeming inconsistency is found in the fact that peak A, which is so helpful in separating safe and unsafe behaviors, is completely absent in the other notch characteristic curves.

The static notched tensile bars normally used in steel comparisons have 50% of their cross sectional area removed by the notching operation, a sharp radius at the bottom of the notch (0.001 in.) and a 60-deg included notch angle. When a test bar of this shape is pulled in tension, it develops tensile stresses in three perpendicular directions below the surface of notch bottom. These stresses restrict the specimen's flow so that 1.5 times as much stress is required to produce a given contraction in area in a notched specimen as would be required to give the same flow in an unnotched specimen of equivalent cross sections. If the stress-strain curves for a notched and an unnotched specimen are compared (see Fig 2), the notched piece will show 1.5 times the stress at any given strain value. This relationship holds at low strength levels.

Notch strength and tensile strength are defined as the maximum load in a notched test divided by the original cross-sectional area, and maximum load in an unnotched test divided by the original cross-sectional area, respectively. Since notched and unnotched bars go through a maximum load at the same strain, the notch strength (for ductile materials) equals 1.5 times the unnotched ten-

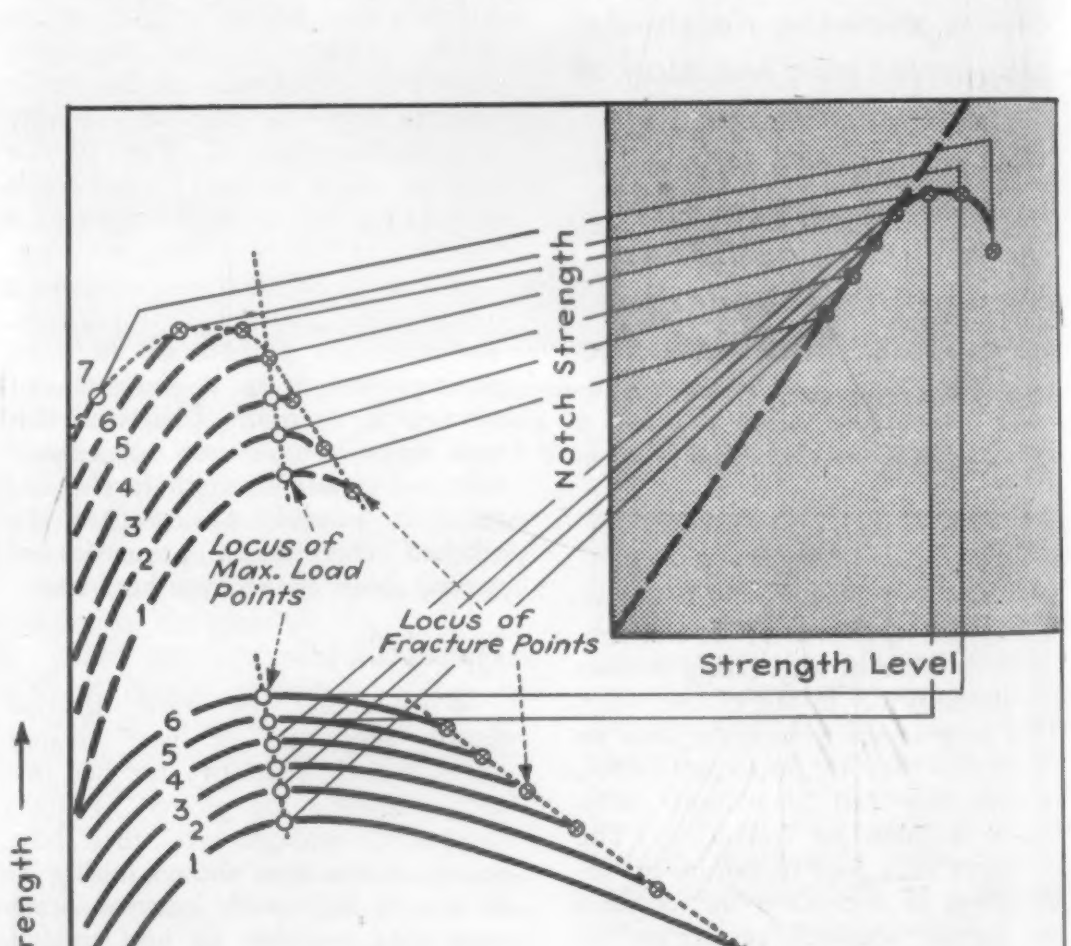


Fig 3—Each pair of these schematic stress-strain curves represents a notched and unnotched test on the same steel. Increasing numbers represent increasing strength levels.

sile strength when the notch shape described previously is used. This relationship depends only on the notch shape and is independent of the material or its strength level, as long as the notch ductility of the material is greater than the maximum load strain.

When a steel has its strength level increased, not only are the general levels of the notched and unnotched stress-strain curves raised, but the steel's ductility (both notched and unnotched) is also decreased. When the notched ductility becomes less than the maximum load strain, the maximum load point in the notched and unnotched stress-strain curves no longer comes at the same value of strain, so that the simple 1.5:1 relationship no longer exists. See notch curves 5, 6 and 7 in Fig 3. The notch strength actually becomes dependent on the notch ductility. The unnotched ductility is also decreased by the increasing strength levels, of course, but the unnotched ductility for any reasonable strength level never becomes less than the maximum load strain.

Each pair of schematic notched and unnotched curves in Fig 3 that bear the same number represents a notched and unnotched test on the same material. The relationship between these maximum load values when they are plotted so that the notch strength is a function of the strength level is shown in the small upper right hand chart.

At the maximum load point the slope of any notched or unnotched stress-strain curve is, of course, zero, so that as the notch ductility decreases in the region of the maximum load, the notch strength-tensile strength ratio changes from 1.5:1 rather slowly (see notched curve 4 in Fig 3). At still higher strength levels, where the notch ductility is considerably less than the maximum load strain, the stress-strain curves are almost straight lines with rather high positive slopes (notch curve 7 in Fig 3). Consequently, any change in ductility is reflected in the notch strength.

Actually, the stress-strain curves in Fig 3 are idealized. At very small strains the shape of the curve might be influenced by the residual stresses formed during quenching. These stresses, however, do not affect the fracture data since even small plastic strains completely wipe them out.

The terminal points on the stress-strain curves at strength levels corresponding to curves 5, 6 and 7 in Fig 3 determine the shape of the low

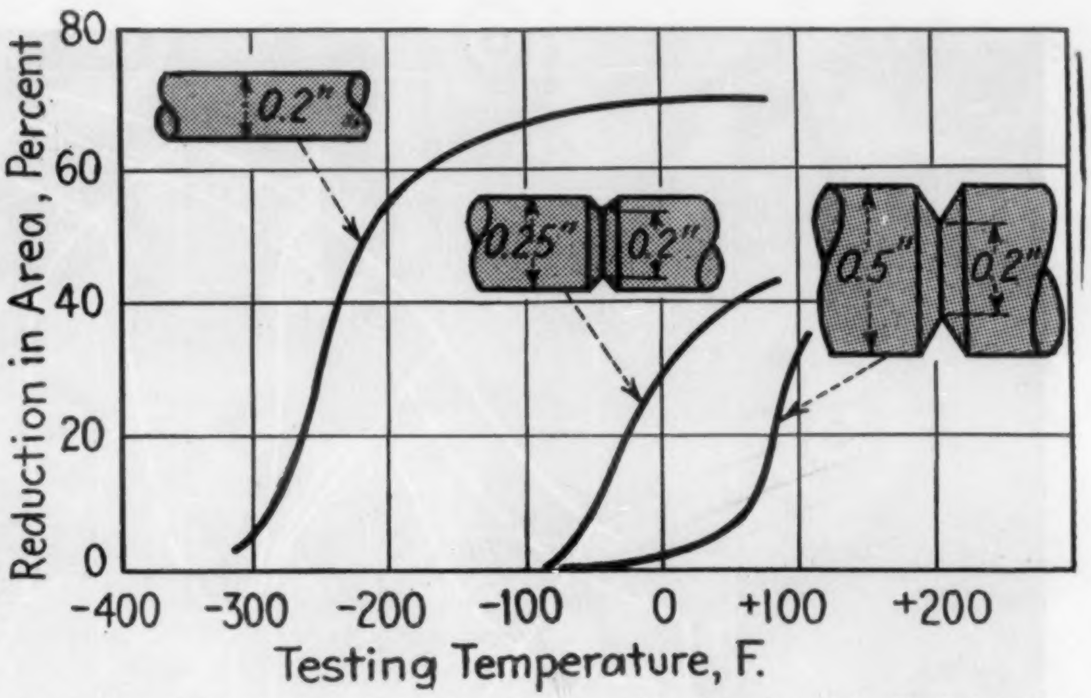


Fig 5—The transition temperature of an 0.17% carbon rimmed steel is effectively raised by increasing the notch severity. (Jones and Worley)

strength level peak in the notch strength-level curve. If the notched ductility decreases rapidly with increasing strength level, the peak is narrow, whereas if the ductility decreases slowly the peak is broad. It

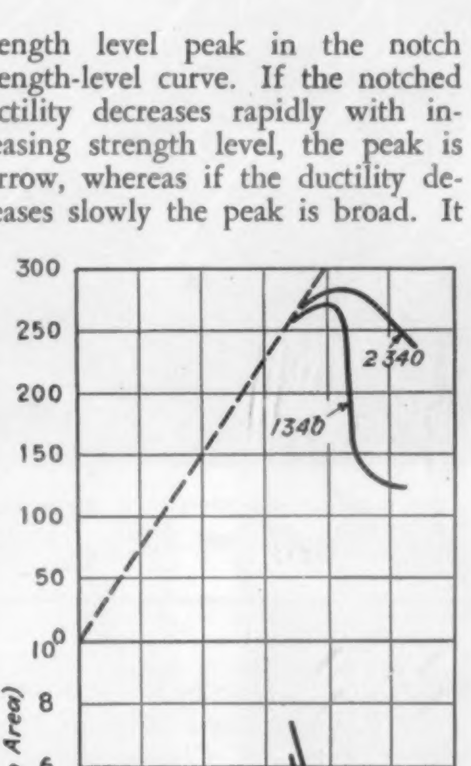


Fig 4—Static notched tensile properties of 2340 and 1340 as a function of the strength level. (Sachs, Ebert and Brown)

is conceivable that the peak might be broad enough to completely eliminate the depression shown in Fig 1.

The experimental data for the notch strength and notch ductility of SAE 2340 and 1340 are shown in Fig 4 as functions of the strength level. The notch ductility for these steels apparently becomes equal to the maximum load strain when the notch ductility is 6%. At strength levels which result in a higher notched ductility than 6% (strength levels less than about 175,000 psi), the notch strength simply equals 1.5 times the tensile strength, as shown by the dashed line. At strength levels higher than 175,000 psi, the shape of the notch strength-strength level curve depends on the notch ductility. Since at strength levels between 175,000 and 200,000 psi the ductility-strength level curves for these steels are parallel, the notch strength-strength level curves are also parallel. At strength levels between 200,000 and 225,000 psi, the ductility of 1340 decreases faster than that of 2340, so that its notch strength curve falls off more rapidly.

Since the peak which had been labeled A in Fig 1 is broader and occurs at a higher strength level for 2340 than for 1340, 2340 would be expected to behave more favorably under severe stress conditions at high strength levels than 1340.

Transition Temperature

One might well wonder why these tempering temperatures (600 and 400 F) and strength level minima and maxima, which are so evident in Charpy and static notched properties, are completely absent in the regular unnotched tensile test. The basis for this difference in the two types of tests lies in the fact that steels exhibit a transition temperature (the temperature at which materials change abruptly from ductile to brittle).

The temperature at which any steel will exhibit this transition from ductile to brittle behavior depends on

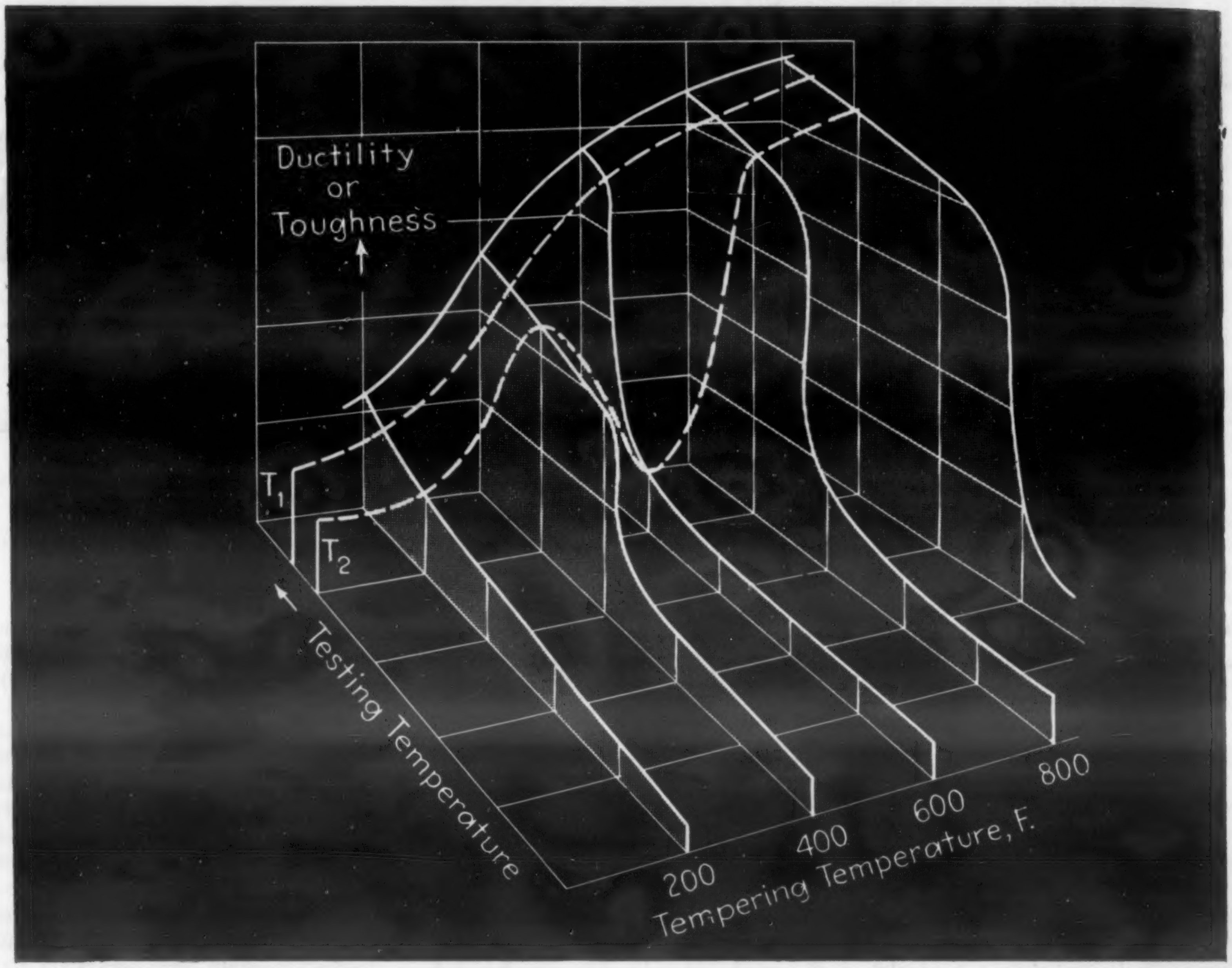


Fig 6—Dependence of ductility, or toughness, on the testing temperature and tempering temperature for a quenched and tempered SAE steel.

the severity of the test used to evaluate the steel's properties.

In Fig 5 are shown the ductility vs. testing temperature curves for a rimmed 0.17 carbon steel tested under three different conditions of notching. The test severity in this series was increased by increasing the notch depth. Other common methods of increasing the test severity are the use of sharper notch radii, smaller included notch angles, or higher strain rates.

Notice that the introduction of the notch causes two changes in the appearance of these curves. First, it lowers the ductility at all temperatures above the transition value. Secondly, increasing the notch severity raises the transition temperature.

Consider this second effect of notching. Since transition temperatures are raised by notches, the notch behavior shown by any steel over some particular testing temperature range can be considered to be the same as that shown by the steel in an unnotched test over a range of lower temperatures. A Charpy or static notched test at room temperature, then, is equivalent to an unnotched tensile test at some sub-zero temperature.

The sub-zero unnotched tensile properties and the Charpy transition temperatures of the quenched and tempered SAE steels are well established. The steels investigated to date all show an increasing transition temperature with decreasing tempering temperature down to a tempering temperature of 500 to 600 F (neglecting any temper embrittling effects). Further lowering of the tempering temperature to 400 F decreases the transition temperature, and it is generally thought that lowering the tempering temperature still further again raises the transition temperature. The ductility vs. testing temperature curves for a quenched steel tempered at 200, 400, 600, 800 and 1000 F are shown schematically in Fig 6. These data represent either the ductility in a notched or unnotched static test, or the toughness in an impact test. For each of these tests the curve shapes are as shown in Fig 6. Only the range of represented testing temperatures would be different for the various types of tests since an increase in test severity is analogous to a decrease in testing temperature range, as explained above.

At a high testing temperature (T_1 in Fig 6 for example) the relationship between ductility and tempering temperature is quite simple. Increasing the tempering temperature results in a continuous increase in the ductility. This is the shape ductility-tempering temperature curve obtained when the room temperature unnotched tensile ductility (contraction in area) is plotted as a function of the tempering temperature. When this same material is tested at a

lower temperature (T_2 in Fig 6), the testing temperature is above the transition temperature for the steel tempered above and below 600 F, but below the transition temperature for the material tempered in the range of 600 F. Consequently, the ductility vs. tempering temperature curve becomes more complex (curve T_2) in that it exhibits a minimum at a tempering temperature of 600 F and a maximum at a tempering temperature of 400 F. Curves of this shape have, as a matter of fact, been found for SAE 1340 and 5140 from unnotched tensile tests conducted at -321 F.

If now the unnotched tensile behaviors at room temperature are compared with the notched (Charpy or static tensile) behaviors at room temperature, the former test is found to produce results of the type shown for T_1 while the latter data result in curves of the type shown as T_2. The introduction of the more severe testing condition (the notch and high strain rate in the Charpy test; the notch alone in the static test) has effectively lowered the testing temperature from T_1 to T_2.

The supposition that the introduction of a notch does nothing more (as far as steel comparisons are concerned) than effectively lower testing temperature implies that, if the notched properties were obtained at a temperature higher than room temperature, the toughness minimum at tempering temperatures of 500 to 600 F would disappear. That such is the case is shown by the Charpy data in Fig 8. Furthermore, notched tests at low temperatures will broaden the 500 to 600 F tempering temperature toughness minima and possibly eliminate the 400 F tempering toughness peak.

Face-Centered-Cubic Metals

One other conclusion to be derived from this analysis is the fact that those metals which do not show a transition temperature (those which crystallize in the face-centered-cubic system) should always show the same trend curves as a function of any variable, whether the ductility is obtained in a regular unnotched tensile test or in some notched test. Consequently, although notched behaviors are extremely valuable in steel property evaluations, one would expect them to be considerably less important in evaluating the mechanical behavior of metals like the aluminum- and copper-base alloys.

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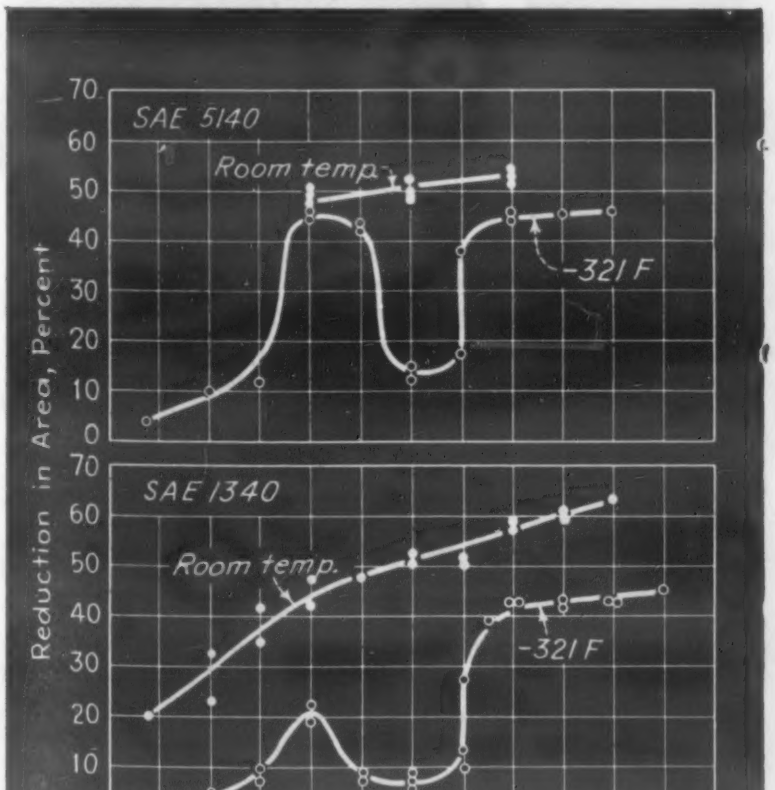


Fig 7—The ductility of SAE steels at low temperatures show a local maximum for a tempering temperature of 400 F even in unnotched specimens. (Ripling)

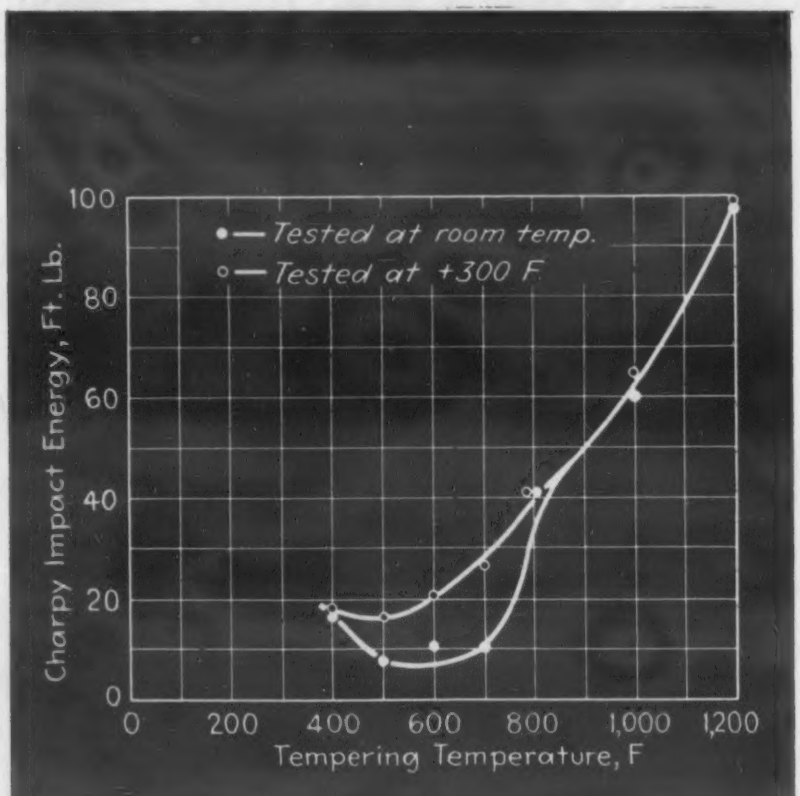
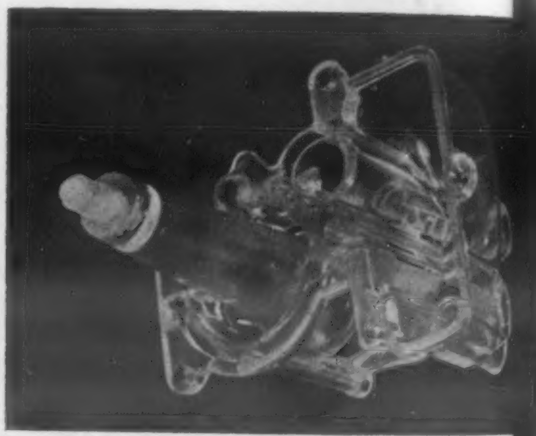


Fig 8—Toughness of SAE 1340 as a function of tempering temperature at a room temperature test and a high temperature test. (Raeyerty, Craig and Sheehan)

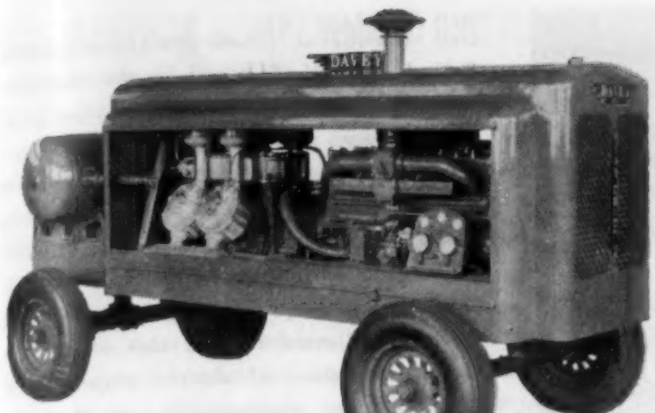
Materials at Work

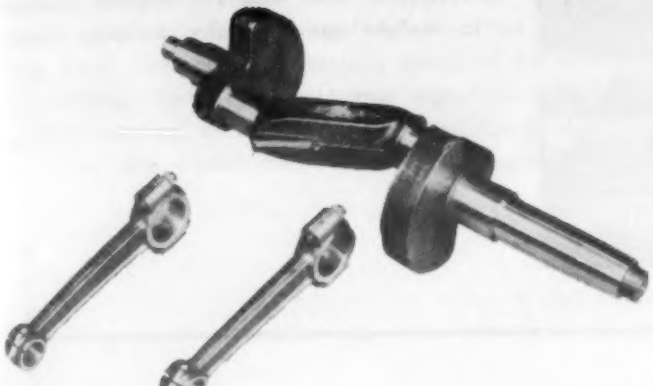
Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .

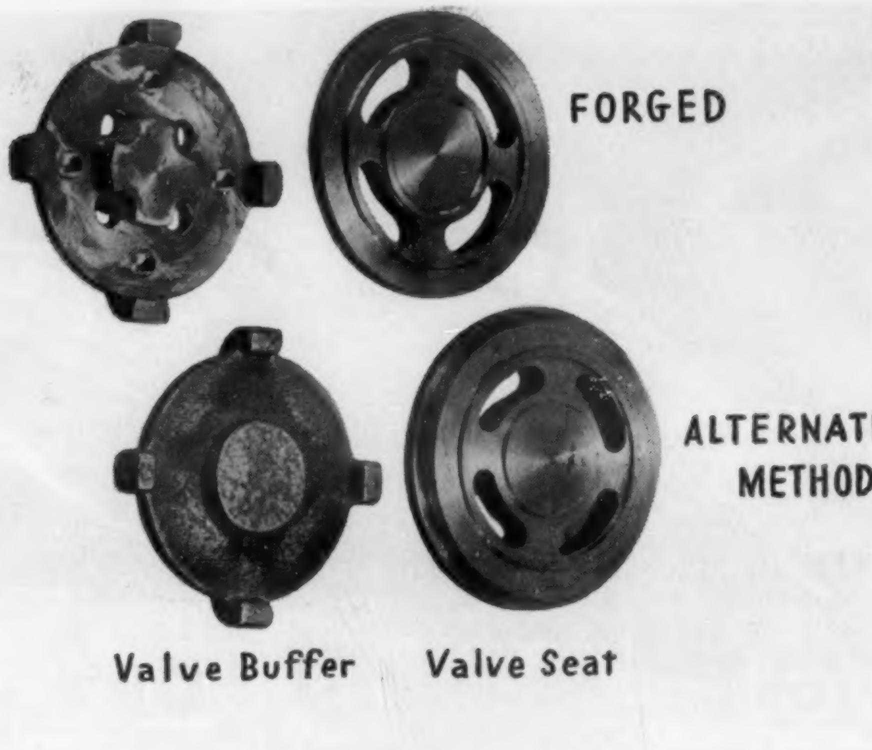
ALUMINUM PT BOATS *This new version of the Navy PT Boat has an aluminum hull and is bigger and faster than the older wooden-hull models. Four of these boats have recently been completed with all-aluminum hulls built on half-welded, half-riveted structures. Two of the boats use all-welded hull construction. Aluminum was used primarily to cut weight and give a faster, stronger boat. The high resistance to salt water corrosion shown by the marine alloys used was also an important factor in the choice of aluminum. Two of the new PT Boats are shown making a high-speed run with the crew at general quarters.*



PLASTIC CARBURETOR *The die that was actually intended to make zinc die castings was used for this injection molded methyl methacrylate carburetor. The transparent plastic part was needed by the Zenith Carburetor Div. of the Bendix Aviation Corp. to allow visual inspection of the internal behavior of the part in action. The close similarity of die casting and injection molding are illustrated by this carburetor, and careful study of the part reveals several points of interest. While plastic parts have far outstripped die castings in point of size, the die casters have in general developed their techniques to a greater degree in the complexity of the parts produced. This carburetor is ring gated through the original zinc gate, approximately 0.020 in. thick. The shutoff between the intersecting pins would make the hair of the average injection molder stand on end. Two intersecting cores of this type are 2½ and 1¾ in. long, unsupported throughout their length. The shutoff is perfect.*

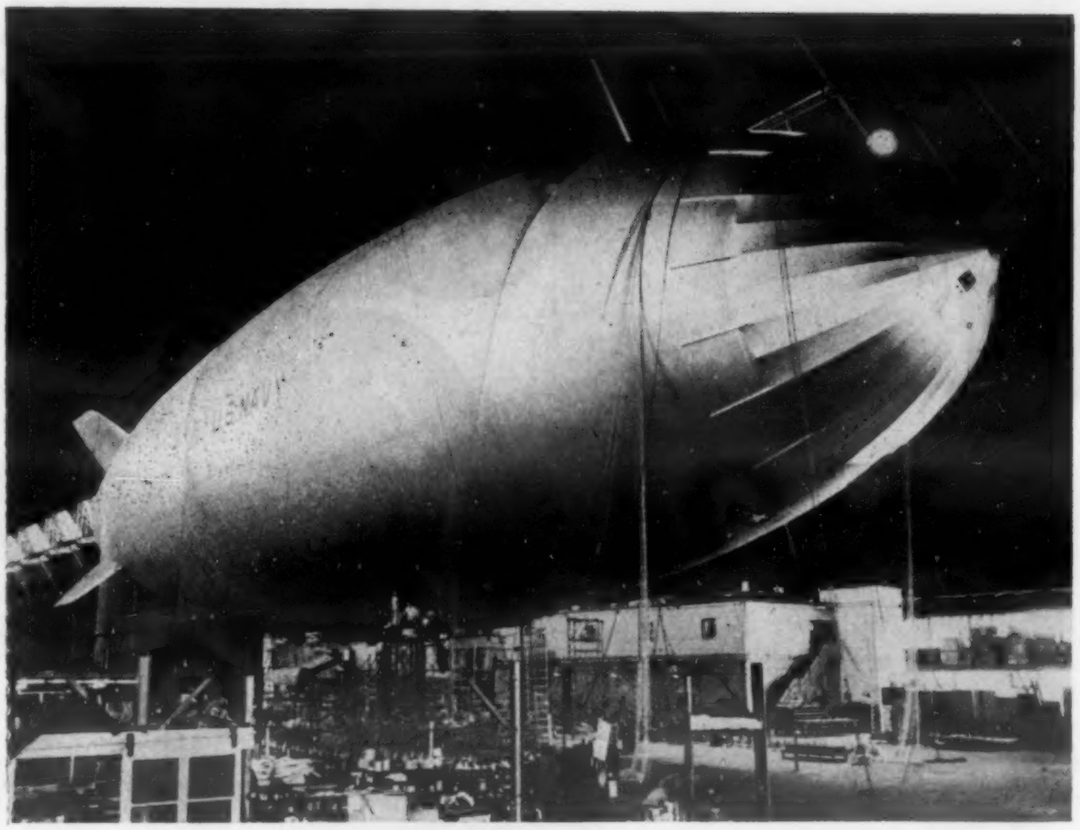




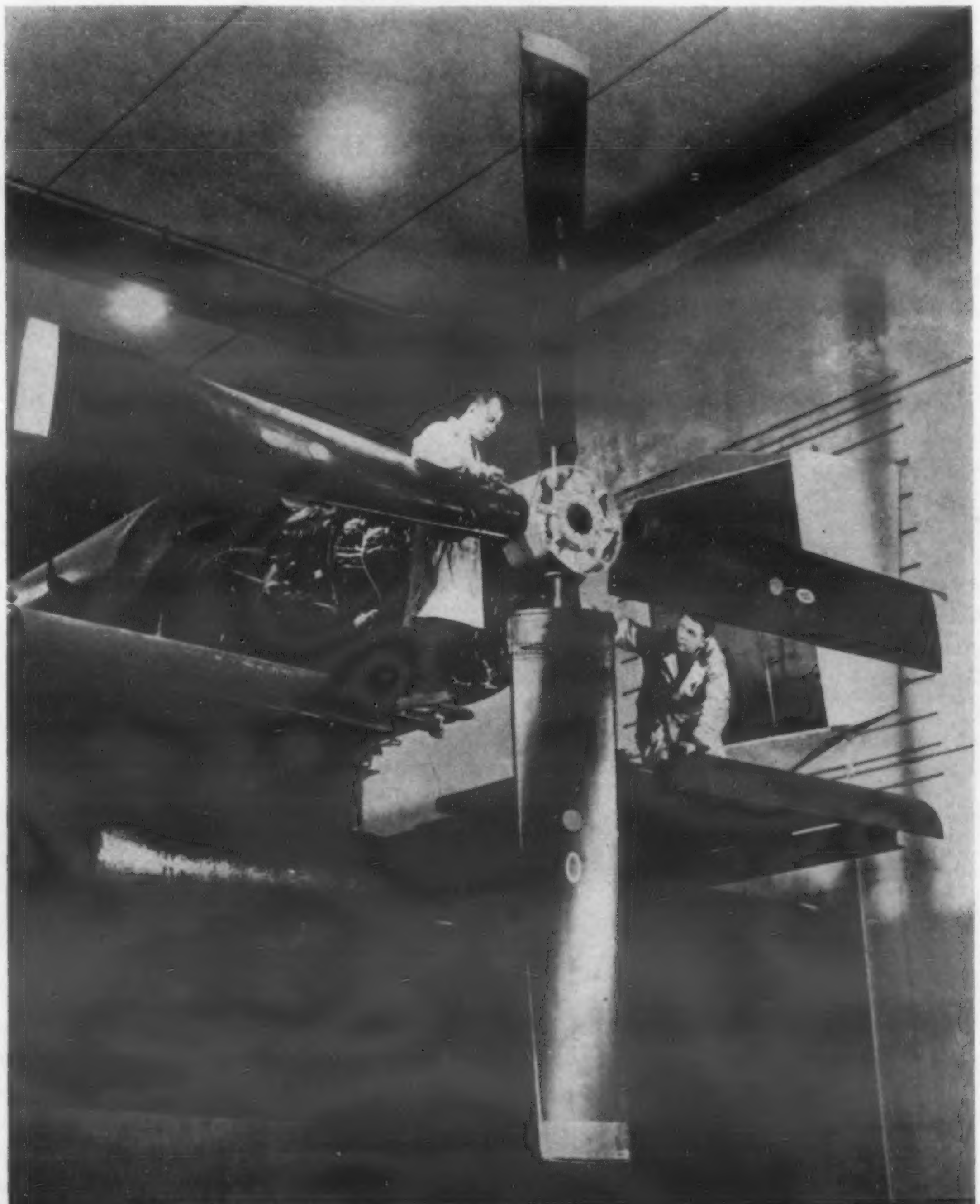


DEPENDABLE FORGINGS SIMPLIFY COMPRESSOR DESIGN

The heavy-duty Airchief compressor, capable of delivering 315 cu ft of air per min at 100 psi, was carefully designed to be light and compact by the Davey Compressor Co. To get this favorable weight ratio the crankshaft and connecting rods are forged of 1045 steel and heat treated to 290 to 321 Brinell hardness. The counterweights, incidentally, are forged integral with the shaft. The designers also used forgings for other vital parts. A special discharge valve with two manganese bronze forgings was designed to retain efficiency without cleaning. The discharge seat is forged to insure dense, nonporous metal surfaces and prevent leakage and inefficiency. Forging also saves machining and cuts the cost of the valve. The power take-off for the truck-mounted Davey Compressor makes even more important use of forgings. The unit is compact and becomes an integral part of the truck drive shaft. All the principal parts are drop forged from 4140 steel and heat treated to Rockwell C30-35. By making the clutch sleeve and drive shaft as forgings, five parts were replaced by two. Forging also gives the parts greater strength and allowed the designers to use lighter cross-sections.



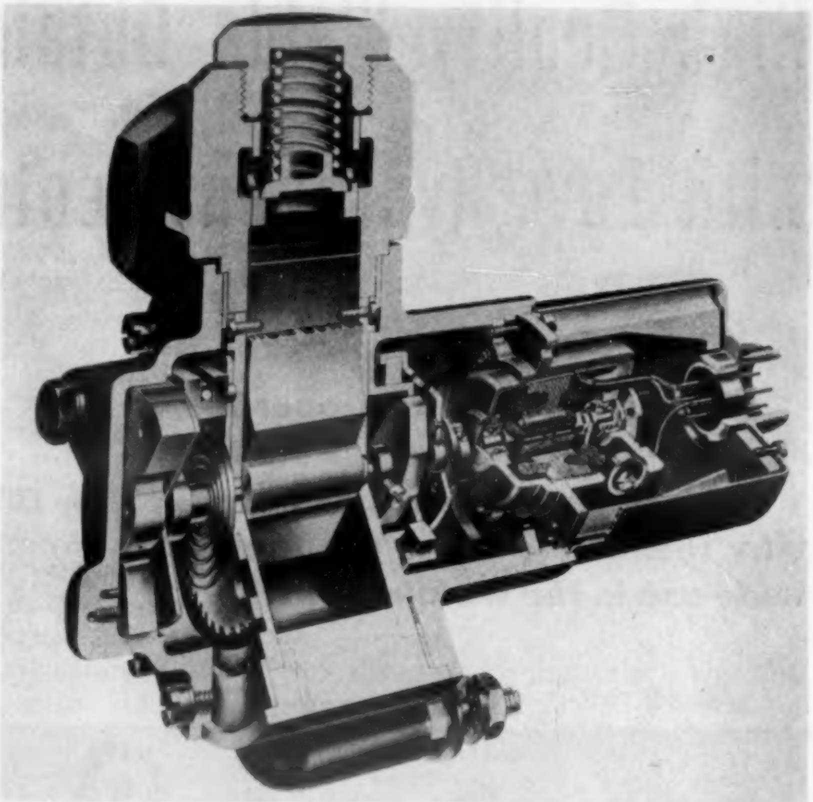
BIG BLIMP *The world's largest blimp, built for the U. S. Navy by the Goodyear Aircraft Corp., is designed for anti-submarine duty. The airship is non-rigid and there are no inner metal ribs to support the helium-carrying bag. Its gas capacity of 875,000 cu ft is almost twice that of the K-type ships used in World War I. The special neoprene-coated rayon fabric that was selected for the skin offered the best combination of desired properties. It has low gas permeability, so that the helium can be held for long periods; its superior resistance to sunlight and weathering was needed to withstand Navy service; it also had the highest strength to weight ratio of any material tested.*

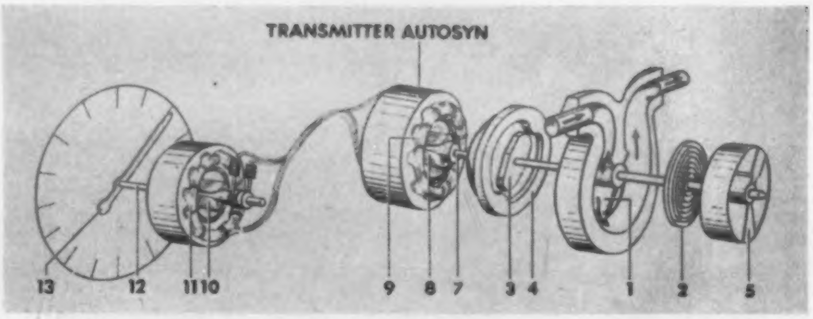


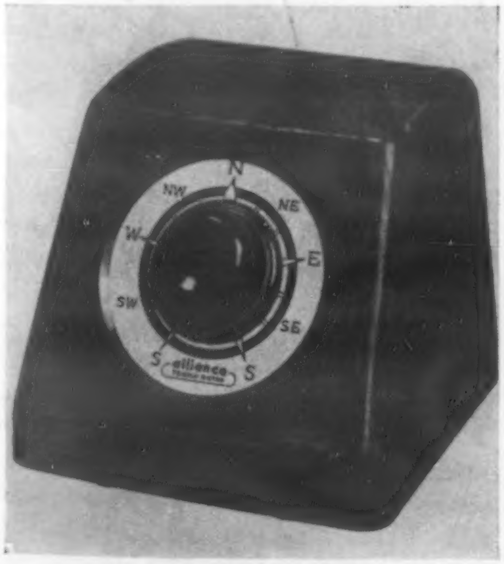
SPONGE-FILLED AIRPLANE PROPELLER *An airplane propeller filled with sponge rubber is now in manufacture at the Hamilton Standard Div. of United Aircraft Corp. Light, hard and strong, the sponge is used to fill the void between the propeller blade core and shell, keeping the shell from vibrating under pressure and supporting it against the impact of stones and ice. The new filling compound called HS160 has three principal ingredients: Hycar OR-15, an oil-resistant rubber made by B. F. Goodrich Chemical Co.; phenolic resin; and nylon. In manufacture, a blowing agent is used to foam the blend up to eight times its former mass, and the resultant sponge cools into a light rigid structure. HS160 has been compounded so that high centrifugal forces will not cause it to shift. It has outstanding advantages over the Ebonite filling formerly used. HS160 is three to four times as resistant to impact, has greater fatigue, tensile and torsion strength, and can be processed in 25% less time.*

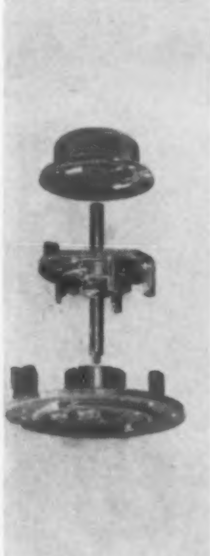
TEMPERATURE COMPENSATED SPRING

The Eclipse-Pioneer aircraft fuel flow system consists of an Autosyn transmitter mounted in the fuel supply line to the engine, and an indicator on the instrument panel. The system shows how fast the fuel is being consumed. Fuel enters the inlet port of the transmitter and moves a vane (1) against the restraining influence of a calibrated spring (2). The position of the vane, indicating the velocity of flow, is transmitted to the Autosyn rotor (7) through the bar (3) and ring magnet (4) coupling. The instrument rotor (10) moves to the same position in its stator (11) that the transmitter rotor (8) takes in its stator (9). The damper vane (5) cushions out the wide fluctuations sometimes caused by air bubbles. The transmitter is built to specifications requiring specific accuracy tolerances over a temperature range of —67 to +150 F. The spring originaly used was beryllium-copper, but the material was changed by a redesign to Iso-Elastic, a patented alloy produced by John Chatillon & Sons, New York. This alloy is specially designed for springs in which the resisting force cannot change significantly over wide temperature ranges. In this fuel flowmeter, Iso-Elastic insures accuracy over the whole range of aircraft operating temperatures.









PLASTIC ANTENNA CONTROL

The Tenna-Rotor, made by the Alliance Manufacturing Co., controls the turning of an antenna from inside the house. Its operation is automatic and a small beam of light in the dial indicates the position of the antenna. The original design for the housing of the unit was molded in two pieces. The new housing is done in one piece and the same part is used in the Tenna-Scope, another Alliance TV accessory. In designing the mold for the control assembly, rejects due to trapped gases in dead-end cavities were minimized by engineers of the Plastics Div. of the Continental Can Co. The molder was able to select a Durez general-purpose phenolic that could be molded to the required close tolerances and provided the desired electrical and mechanical characteristics.

TINY NICKEL THERMOMETER

The RdF Stikon, made by Ruge-deForrest, Inc., is said to be the world's smallest commercially available thermometer. Cemented to the surface, it measures temperatures from —100 to 400 F with the accuracy of 1 F. The active part is a minute grid of nickel wire, uniformly drawn to 0.0008-in. dia. The grid itself weighs about 64 millionths of an oz. Measurements are made with a resistance bridge, and nickel was chosen for this grid because of its high coefficient of electrical resistance which makes temperature changes relatively easy to measure.

High Quality Welds Obtained with Low Hydrogen Electrodes

Outstanding weld properties, savings in critical materials and reduced costs are some reasons why these electrodes are finding wide use in the welding of steels.

by EDWIN LAIRD CADY

Arc welding large lawn mower blades using low hydrogen electrodes.

● LOW HYDROGEN WELDING electrodes made their commercial appearance about 11 years ago. Originally their purpose was the elimination of under-bead cracking when welding hardenable steels. Since then their value has been demonstrated in many ways. The physical properties of welds are, in general, improved and, in some cases, welding speeds are increased. The needs for preheating and stress relieving operations have been largely reduced and even eliminated. They can be substituted for stainless steel rods at substantially reduced costs, especially wherever the austenitic properties of the weld are desired. These and other qualities have made them highly useful wherever welding is done.

In the AWS-ASTM filler metal specifications, low hydrogen electrodes make up the EXX15 and EXX16 classifications. The "XX" in these designations will be either 60, 70, 80, 90 or 100, depending on the tensile strength of the deposited metal. Thus, an E7015 electrode would provide a minimum tensile strength of 70,000 psi.

Low hydrogen electrodes consist of low carbon steel wire cores with coatings containing the alloying ingredients desired in the weld metals. The coatings are of two general types: a lime type consisting of a mixture of lime and titanium used only in d.c. welding, and a high titanium type used in either a.c. or d.c. welding. They have an extremely low content of hydrogen-containing materials, thereby permitting welds free from the effects of hydrogen. They also provide an easy method for introducing selected alloying elements into the weld metal so that commercial demands for new types of rods can be quickly met if they are required.

Welding techniques using low hydrogen rods are approximately the same as those used with stainless steel rods, and anyone who has used stainless steel will have little trouble with them.

Advantages

Welding operations using low hydrogen electrodes are very often faster than those in which ordinary rods are used. Not only are they faster, but the quality of the welds is better. The welder tends to have greater confidence in his work and is inclined to proceed more rapidly. In one instance, thin section hardenable steel pieces were welded to thick section nonhardenable steel ones. The operation required mounting several pieces on a jig, making 25 welds which were hardly more than tack welds, and removing the completed assembly from the jig. Previously, the time required had been 3 min, but this was cut to 2½ min with low hydrogen rods. Rejects for faulty welds were reduced from 50% of all assemblies to the order of two per 500 or 600 assemblies. Rejections due to warpage caused by heat variation were also much reduced through use of the faster rods.

Use of low hydrogen electrodes has greatly reduced preheating and postheating requirements. Where preheating is required, as in the welding of armor plate 4 in., or

greater, in thickness, the preheat temperature has been cut from 600 to 800 F to 300 to 400 F. This has permitted the use of ordinary arc welding for adding small parts when submerged arc welding was used for the main assembly welding.

Stress relief operations can be reduced, or eliminated, partly because of higher welding speeds, and partly because they are largely hydrogen-eliminating operations not needed with low hydrogen rods. This has been demonstrated in the results of laboratory tests in which welds made with conventional 60-10 electrodes showed a tensile strength of 75,000 to 80,000 psi with 17 to 20% elongation immediately after welding. When tested 48 hr after welding, however, the tensile strength dropped to 60,000 to 70,000 psi and the elongation increased to 22%, or more. Stress relieving produced the same effects but achieved them more rapidly. By comparison, low hydrogen weld metal of similar analysis showed a tensile strength of 70,000 to 80,000 psi with a 22% elongation immediately after welding and showed no significant change with time.

Weld Characteristics

Tensile strengths of welds obtained using low hydrogen welding electrodes closely approach those of the base metals. Up to 120,000 psi can be obtained with some rods if the weld is stress relieved, 125,000 psi if it is not. The higher strength, however, is accompanied by a slight loss of ductility.

The impact strengths of the low hydrogen weld metals can be higher than those of any other weld metals throughout a wide temperature range. Thus, the weld metal of one hydrogen rod has an impact strength of 108 ft-lb at room temperature as compared to 40 to 60 ft-lb for the weld metal of a conventional rod of similar analysis. At –60 F it has an impact strength of 40 ft-lb as against 20 to 30 ft-lb for the conventional weld metal. Sometimes this permits higher operating speeds of machines in which welded assemblies are subject to shock loading. In one machine, unavoidable shocks had had a tendency to break the welds of thin members so that the machine had to be stopped. When the welds were made with low hydrogen rods they held; if any breakage did occur it was in the form of small pieces broken from the thin members. This was usually not enough to require stopping the machine, and operation could be continued until repairing was convenient.

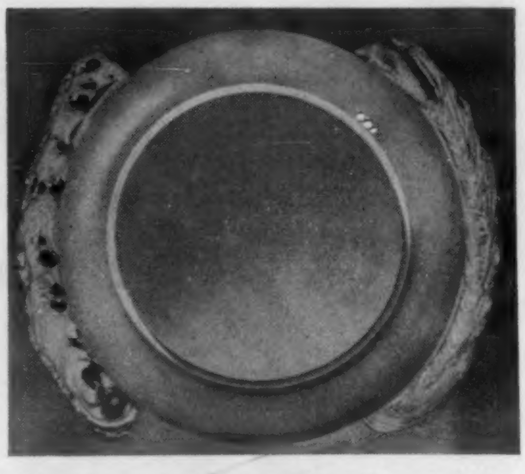
Low hydrogen weld metals are largely free of porosity since hydrogen evolvement is one of the prime causes of porosity in metal. This permits the modification, in some instances, of the sizes and shapes of weld groove and the reduction of other fit-up problems when these rods are used.

Applications

One of the most frequent uses of low hydrogen welding electrodes is in the fabrication of weldments from hardenable steels. A prime hazard encountered in welding these steels is under-bead cracking caused by the presence of hydrogen in the weld metal. It is especially great when the parts are fabricated to shape, welded into assemblies, and the assemblies heat treated to harden the base metals. It was the original purpose of low hydrogen welding rods to provide a solution to this problem and it still remains as one of their largest uses.

High-sulfur, free-machining steels can also be welded with low hydrogen electrodes. In one application, parts for electric drills and other small power tools were formerly cast to shape and then machined. Now they are made partly of screw machine parts of high-sulfur steel and partly of shapes stamped from the same kind of steel. The stamped parts are assembled from simple blanks, or shapes, simply by welding them with low hydrogen rods and then further stamping or otherwise forming them into the final shapes. The screw machine parts are similarly welded to the stampings, or to each other, to create final assemblies. The results are lighter weights, better appearance, and the elimination of many design problems.

Where stainless steel electrodes have been used to obtain an austenitic weld metal rather than used for corrosion resistance alone, costs heavily favor the use of low hydrogen rods to produce substantially the same weld metal characteristics. With the use of less than 2% of any one alloy a low hydrogen rod often can replace an 18:8 stainless rod. The cost in one instance was $1.25 a lb for stainless electrodes as compared to $0.14 a lb for low hydrogen electrodes to get the same result in the weld. Cast steel valve bodies containing 1% molybdenum and 2% chromium, formerly welded with stainless steel

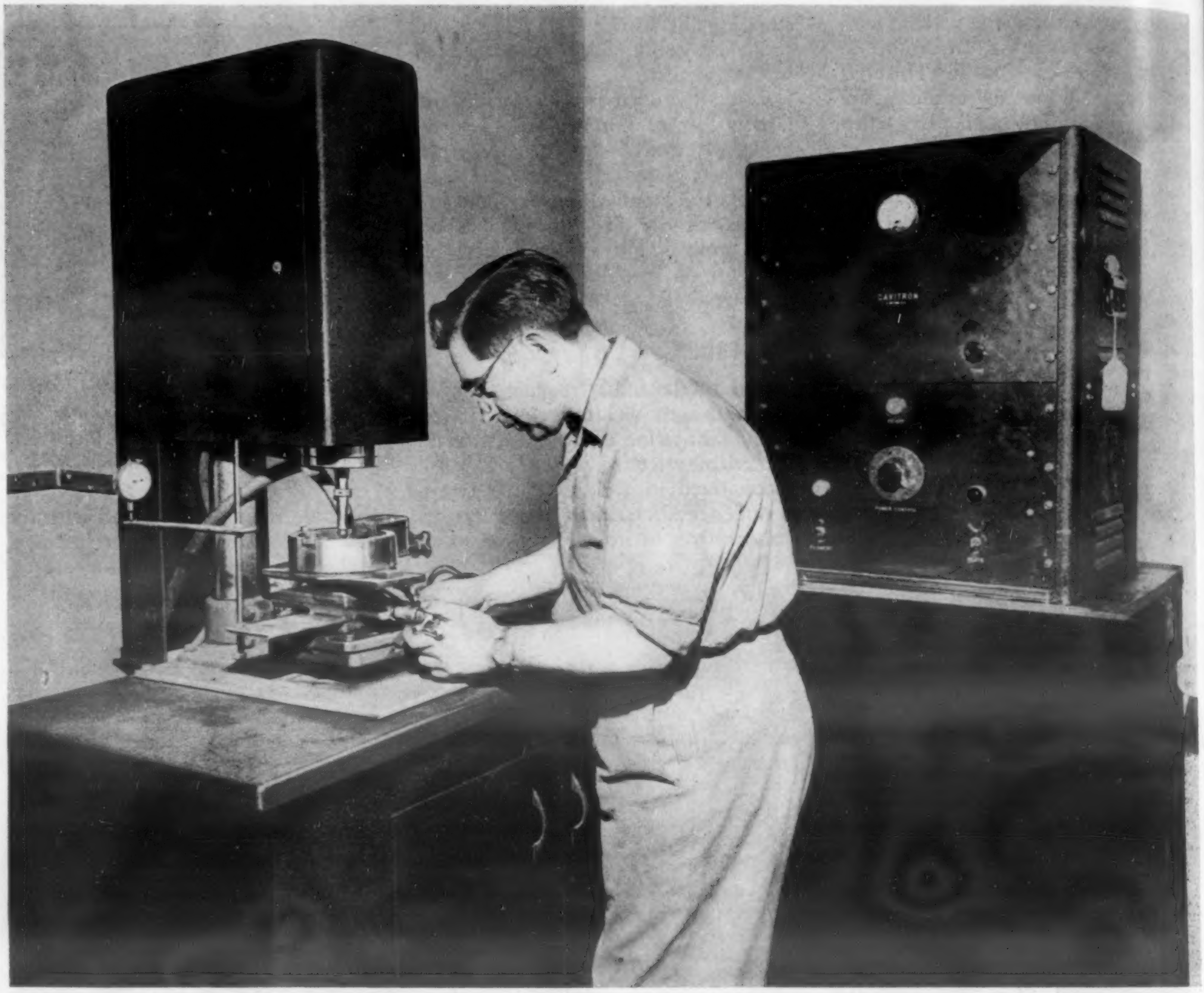


Advantage of using low hydrogen rods for welding high sulfur steel is shown in comparison of low hydrogen weld (right) with mild steel weld. (Air Reduction Sales Co.)

rods, are now being welded with the low hydrogen type. High-pressure, high-temperature power piping is another use. Since the techniques for using the two types of electrodes are much the same, the low hydrogen type is also being used to train welders who later will use stainless rods. In addition to the costs savings, of course, savings in critical materials are also important considerations where low hydrogen rods are used in place of stainless rods.

Where steels are of highly diverse, or perhaps unknown compositions, the low hydrogen electrode is the safest to use. An alloy steel gear formerly was brazed to its shaft but now is welded with low hydrogen welding rod with a consequent saving of hard-to-get brazing rod. For repair and structural purposes such diverse steels as railroad rails, re-rolled rails and various analyses of structural steels have been welded with low hydrogen rods. The repairing of machines in which the steel analyses are unknown is most easily and safely done by the use of this rod.

Vitreous enameling, a field by itself, is an example of what can be done. Here the presence of any free hydrogen in the weld metal will result in blistering of the enamel, and, although stress relieving operations prevented most of this trouble, the ability of the low hydrogen rod to end the need for the stress relieving is a saving. Also, a mild steel type of low hydrogen rod deposits weld metal so exactly matching the hardness of the parent metal that grinding the weld down to true flatness with the parent metal is accomplished without leaving those minute variations which result in "ghosts" or uneven appearances on the surfaces of the finished enameled items.



The Cavitron, showing machining unit on left, power supply at right.

Hard, Brittle Materials Machined Using Ultrasonic Vibrations

by S. G. KELLEY, Jr., Assistant Editor, Materials & Methods

This new process, employing abrasive particles and ultrasonic vibrations, efficiently shapes complicated forms in difficult-to-machine materials.

● HARD, BRITTLE MATERIALS, usually difficult to shape even by grinding, chipping or engraving operations, may soon be appearing in shapes hitherto considered out of the question. A new process, known as Cavitron, using light pressure, abrasive particles and ultrasonic vibrations seems to have hit upon a combination of conditions which result in a highly efficient breaking down of such materials. Operations, including drilling, boring, threading, cutting and the like, can all be done easily and quickly in comparatively complicated shapes.

How It Works

Unlike most equipment for machining materials, the Cavitron machines by a process which is essentially greatly accelerated wearing. The tool, operating head-on into the work, vibrates at an ultrasonic frequency of about 27,000 times a sec., and an economical abrasive compound (boron carbide) is poured onto the contact area. As the tool vibrates, the abrasive particles, generally 280 mesh, flow between the tool and the work piece. When the tool descends on the particles it drives them into the material being machined, thereby forcing the removal of small particles of the work-piece by a kind of chipping action. These are transported from the work area by the continuous flow of the abrasive compound.

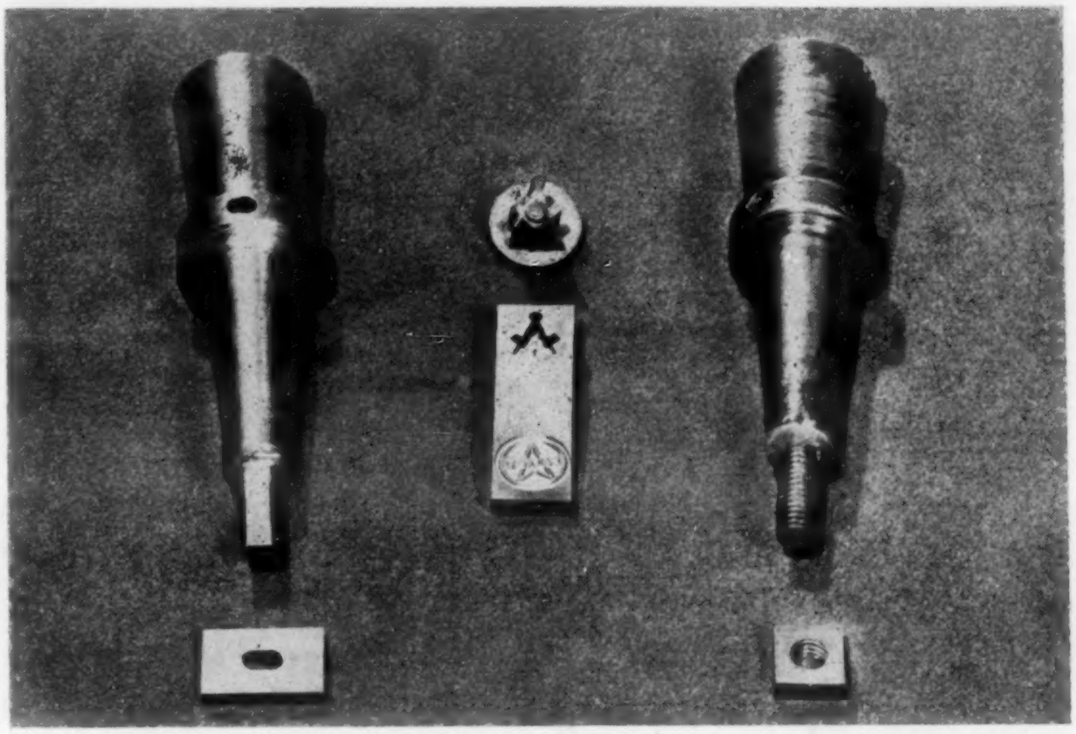
The tool is made of soft steel, such as 1010 or 1065, in the shape of the form to be removed and is soldered or brazed to the small end of a truncated metallic cone. All motion of the tool originates in this cone, which produces movement by expansions and contractions caused by magnetostriction. The cone is available in either of two sizes to give a choice of strokes. One yields a stroke of 0.0015 in. and the other one of 0.002 in.

The abrasive compound is recirculated through the machine and used repeatedly until its abrasive qualities are expended. A single charge generally lasts an average of three weeks before it must be replaced with new abrasive, although this time varies with the type of material being worked.

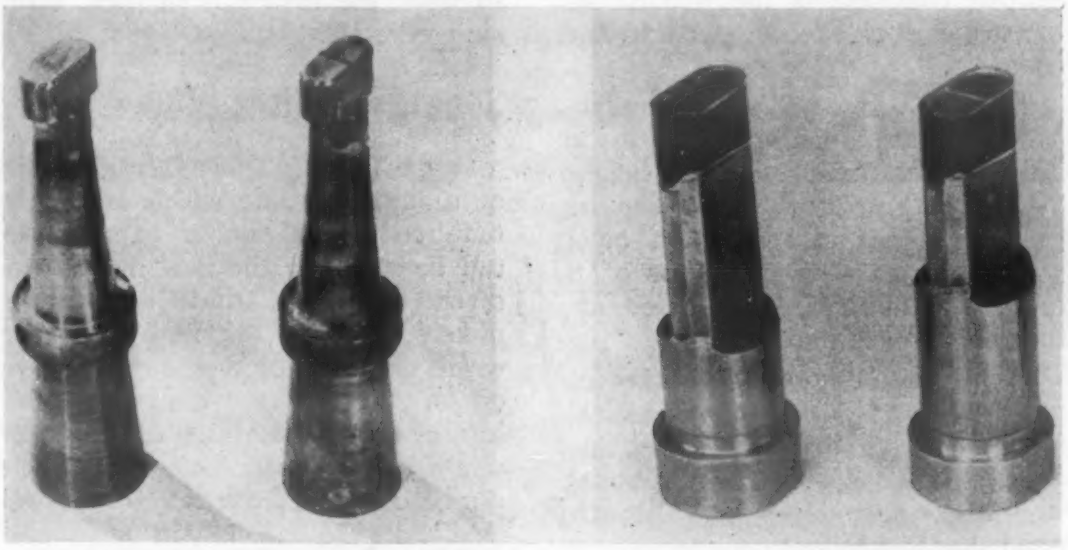
Capabilities

The unique operating principle of the new machine makes it applicable to the economical machining of all types of hard materials. Such substances as glass, ceramics, porcelain, agates, sintered zirconium boride, sintered aluminum oxide, alnico, sintered tungsten carbide, and hardened tool and die steels, all relatively difficult to machine, can be given quite complicated shapes by this process. Soft materials, on the other hand, including lead, rubber, plastics and fibrous substances, are not suited to this type of machining but tend to absorb the abrasive particles rather than to chip under their impact.

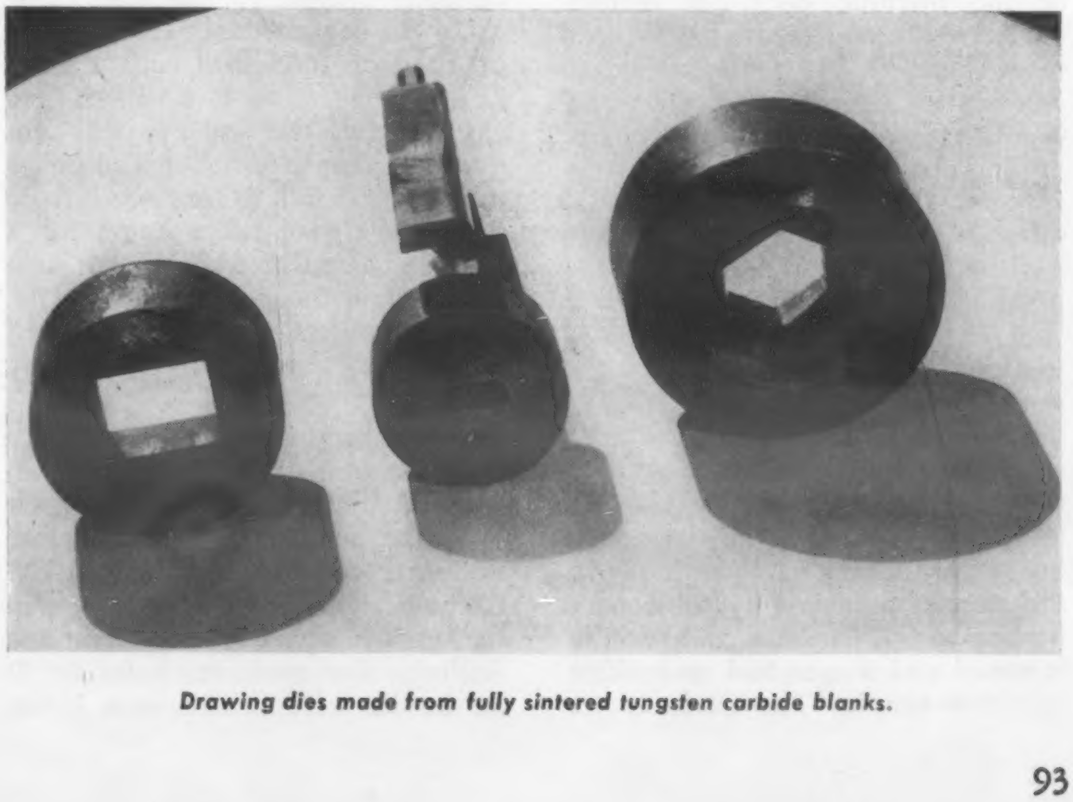
Several advantages over older methods are afforded in the use of the new process. It provides a simplified method of machining very hard materials accurately and requires



Carbide samples (center) with the tools that produced them. Tool at upper center is removed from cone.



Left: Tools and cones used to make carbide pill press punches. Right: Carbide pill press punches claimed to be more durable than those made by usual methods.



Drawing dies made from fully sintered tungsten carbide blanks.

Closeup of tool in position for machining. Tubing coming in from left supplies abrasive mixture.

relatively unskilled workers to operate it. The only operation requiring skillful handling is the making of the actual tool to be brazed to the cone.

The method machines to an accuracy of 0.002 in. and yields a matte finish with a mean roughness height of about 15 microns. This can be reduced with one application of a wire brush to a mean height of 8 microns, although in many cases further finishing is unnecessary.

It has the additional advantage of not heating or changing the physical structure of the material being machined. As a result, no additional stresses are introduced into the material due to unequal cooling.

Costs are low due to the simplicity of the apparatus. With few moving parts, wear and maintenance costs are comparatively slight. Operation of the machine does not require skilled personnel, hence labor costs, often high for the type of work done, are also low. Furthermore, because the Cavitron is self-operating, it is possible for one operator to use several machines at one time, making production a fairly continuous process by producing several pieces at once.

Sintered materials, such as tungsten carbide and certain ceramics, are generally recognized to fall among the most difficult materials to machine. Where any quantity of material has had to be removed, it has been done before sintering except for final reduction to size. As a result, the stresses produced by subsequent heating to full hardness could not be removed and shapes had to be kept relatively simple. The Cavitron has made possible a wide assortment of new shapes because it is now feasible to work the materials in their fully sintered state.

Some Applications

A hexagonally shaped drawing die of tungsten carbide which originally required several weeks to machine can be made by the new method in several hours. Carbide nuts, completely threaded, can now be made, while drilling holes of any shape is one of the simplest operations. Some idea of the rate at which the machine wears its way into tungsten carbide can be obtained from the fact that an oval hole 1/4 sq in. in area was drilled through a piece 0.125 in. thick in 18 min.

The forming of images similar to engravings in very hard materials can be accomplished rapidly and easily using the new method. Using a tool of 1010 or 1065 steel with a hardness range of 42 to 45 Rockwell C to ensure detail, the Cavitron will produce in a couple of minutes an image in a material such as tungsten carbide that might have taken hours for a skilled engraver to fashion. For such applications the tool is simply the reverse impression of the required image and generally is used only once before discarding.

The apparatus is well adapted to the formation of intricate shapes in hard materials. Small holes, difficult to make in ceramic parts before sintering, can be produced quickly, economically, and with greater efficiency than when done by diamond drilling. For example, holes 0.032 in. in dia were drilled in a 1/2-in. thick piece of aluminum oxide in approximately 2 min. A hole 1/4 sq in. in area was drilled through a piece of glass 3/8-in. thick in 1 1/2 min. This may seem remarkable, but the fact that the shape of the hole does not affect the speed with which it is produced is probably more significant.

Ceramic bases for printed radio circuits produced in small quantities had previously presented problems in requiring oddly shaped holes and depressions. In the particular case cited it was more economical to do the machining in the fully hardened state, a difficult operation using ordinary methods due to the brittle hardness of the material and the assortment of shapes required. Because it can use tools shaped to fit the hole and will penetrate hard materials without damaging them, the Cavitron has proved a satisfactory solution.

The time required for the manufacture of jewel bearings for precision instruments is being cut considerably. Some idea as to its potentialities in this application may be obtained from the machine's performance in drilling a 1/4 sq in. hole through a synthetic ruby 0.035 in. thick in slightly less than a minute.

Hardened high chromium steel drawing and piercing dies can be made in much shorter time. One producer reported that the cost of producing a certain die was reduced from $85 to $35 through use of the new equipment. In general, it is expected die costs will be reduced by at least one-half.

Alnico is another material which can be shaped by the new process. Not necessarily hard, but tough and highly difficult to machine by usual methods, only simple operations are usually done on it. Cavitron aroused interest at a recent display at which the difficulties encountered in machining alnico had been pointed out, when a square hole, 1/16 in. on a side, was drilled 1/4 in. into the material in 1 1/2 min.

An interesting example of the machine's capabilities was brought out when one user tested it for drilling holes through diamonds. It went through the test diamond so rapidly the diamond was thought to be fractured until subsequent examination proved it was not.

These are but a few of the applications to which the Cavitron has been put. As further work continues to be done with the process, many new uses for it will probably be discovered.

Rare Earths in Aluminum Baths Give Attractive Hot-Dip Coatings

by **WEBSTER HODGE,** Asst. Supervising Metallurgist, Battelle Memorial Institute, and

E. M. SMITH, Flat-Rolled Products Development Engineer, The Youngstown Sheet and Tube Co.

The addition of rare earth alloying metals to hot-dip aluminum baths gives smooth coatings on mild steel parts without the use of a flux.

● ALUMINUM-COATED wide steel strip has been successfully produced commercially for some years. Less attention has been given to hot-dip coating of wire and narrow strip, and still less to the coating of miscellaneous steel products. Such materials are amenable to aluminum coating, however, and the general process offers great promise for commercial work. In particular, progress has been made on the use of alloying constituents in the aluminum bath to give an attractive surface to the work and to aid in avoiding the use of a flux.

Problems

Hand dipping into an unprotected molten aluminum bath presents two main difficulties. One of these is that the last edge of the piece to be immersed, which is normally the first to emerge from the bath, is usually incompletely coated. The other difficulty is that the coated section, although otherwise satisfactory, shows pimples or blobs of oxide or dross distributed irregularly over the surface. Nevertheless, corrosion resistance, as gaged by high-humidity tests, is excellent on all well-coated parts.

The use of a liquid flux adds to the difficulties in obtaining an attractive, bright, smooth, corrosion-resistant coating on irregular-shaped mild steel parts. Complicated gas fluxes and protective atmospheres over the bath should also be avoided.

While many refinements in methods of preparing and handling the steel sections during coating have been developed, it is necessary to change the character of the bath itself if satisfactory work is to be produced.

Aluminum Alloy Baths

Small amounts of magnesium and beryllium, magnesium and lithium, or a combination of these, decrease the rate of oxidation and eliminate oxide skins on molten aluminum. Silicon additions to aluminum baths used for hot dipping of steel reduce the amount of brittle iron-aluminum compounds formed at the iron-aluminum interface.

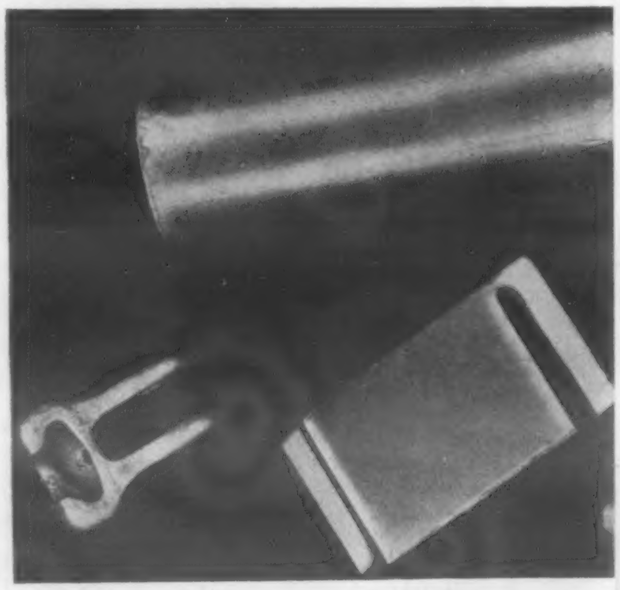
Experimental work has demonstrated that fairly good coatings can be obtained in baths of pure aluminum and of aluminum-5% silicon alloy. The addition of magnesium increases the amount of oxide skin on the bath surface. The addition of lithium and beryllium, or of lithium alone, to baths containing magnesium, or magnesium and silicon, does not decrease the amount of oxide sufficiently to permit alloys of this type to be used for hot-dipping baths. Although the best coatings obtained are complete and highly corrosion resistant, they are unsatisfactory in esthetic appeal. Spots of dross, or discolorations from oxide stains, are found on almost all test panels.

Salt Fluxes

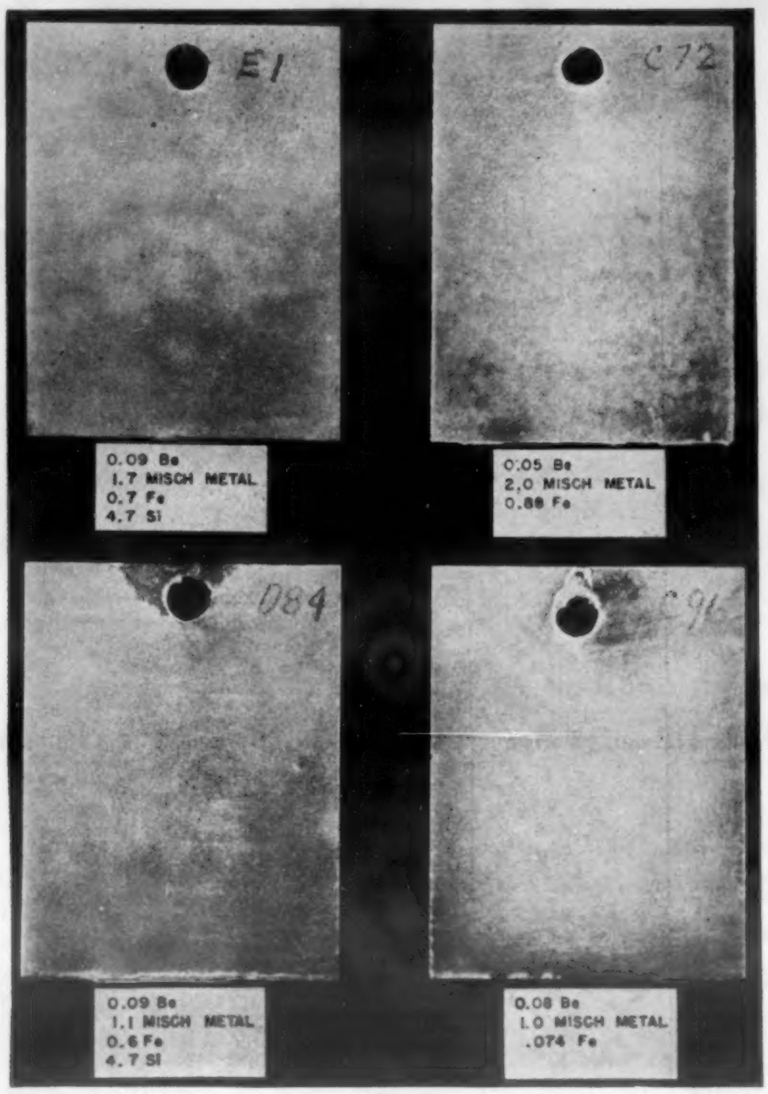
The use of flux coverings on the bath is also unsatisfactory. If sufficient flux is used to clear the surface of oxides, some flux invariably becomes entrapped on the surface of the part being coated. The entrapped flux is difficult to remove and usually leaves discolored spots. Flux residues which are hygroscopic in nature cannot be tolerated.

Aluminum-Beryllium Alloys

Minute amounts of beryllium added to an aluminum dipping bath effect a measurable improvement. With additions of beryllium as small as 0.004%, the oxide skin on the bath maintains its bright metallic luster for a much longer time after scraping than the same bath without beryllium does. This beryllium content will not decrease the roughness on the coated surface, but it does help in eliminating oxide stains. Increasing the beryllium content to 0.014% causes a further improvement in the surface of the bath, but larger additions of beryllium do not appear to help in a pure-aluminum bath. However, an addition of



Miscellaneous parts aluminum-coated using a bath containing small amounts of misch metal and beryllium.



Coatings made from aluminum baths containing beryllium and misch metal additions are smoother and more attractive when silicon is added to the bath.

0.018% beryllium to an aluminum-5% silicon bath immediately benefits the coatings.

Effect of Cerium

The roughness caused by adhering dross and the tendency for considerable aluminum to be held at the drip edge on hot dipping points to the need for reducing the surface tension of the metal or dissolving the oxide film. The addition of cerium looks like a logical step. Cerium is known to be a powerful reducing agent. Since cerium is probably the only metal which has higher molecular heat than aluminum, it can be used to dissolve the skin of Al_2O_3 which forms on the surface of molten aluminum.

Misch metal, an alloy of about 48 to 52 cerium, approximately 38 lanthanum, balance neodymium, praseodynium, terbium, yttrium, illinium and samarium, with about 2 iron and 0.1 to 0.3% silicon, has the same effect in an aluminum alloy as cerium. Misch metal is cheaper and more readily available than pure cerium. For these reasons, misch metal, rather than cerium, was used in the experimental work on hot-dip aluminum coatings.

Misch metal, added to pure-aluminum baths, increases and thickens the amount of oxide on the bath. However, the increased thickness of the oxide surface does not increase coating difficulties. Instead, the iron-aluminum compound, which causes lumps to appear on the coated surface without the misch metal addition, is dispersed and distributed uniformly throughout the coating.

Chemical analysis shows that the iron content of the oxide dross formed on baths containing misch metal is higher than that of the bath from which it was skimmed. When steel wool is dissolved in a bath containing misch metal until lumps of iron compounds appear in the coatings, the addition of more misch metal will again disperse the compound. With a high iron content in the bath, the compound appears as fine pin points, making the coating rough in appearance. About 2% of iron is the maximum that can be held in solution in an aluminum bath at 1350 F in the presence of misch metal.

Composition of Aluminum Coating Bath for Fabricated Parts

	% by Weight	
	A (New)	B (Used)
Misch Metal	1.8	1.5
Beryllium	0.5	0.18 to 0.23
Iron	0.7	1.2 to 2.0
Aluminum (Commercial)	Balance	Balance

Rare Earths and Beryllium

Beryllium in amounts up to 0.2% in an aluminum-5% silicon bath improves the appearance of test panels. However, the coatings tend to be incomplete. When 1.7% of misch metal is added, complete and attractive coatings are obtained.

Although initial appearance of the coatings is improved by having about 5% of silicon in the coating bath, coatings containing silicon tend to darken on prolonged exposure. By careful manipulation, equally good coatings can be obtained in essentially silicon-free baths. These silicon-free coatings have good tarnish resistance.

Improved Ductility

Silicon and magnesium (7.5 to 9.5 Si, 2 to 2.5% Mg) decrease the amount of alloy layer, or aluminum-iron compound, formed in the coating bath, and increase the ductility of the coatings. Bend tests on coated panels demonstrate that similar results are obtained with coatings containing beryllium and misch metal. Although very small beryllium additions are sufficient to clear the bath surface and prevent the formation of oxide stains, a beryllium content of about 0.25% or over is required to obtain greatly improved ductility. Improved ductility is also obtained in coatings from baths containing both beryllium and silicon.

Applications

One bath selected for coating fabricated parts has the composition shown in Column A of the accompanying table when new. After additions, oxidation, settling of iron-aluminum compound formed during use, etc., the bath composition becomes approximately fixed at the composition shown in Column B of the table.

The use of aluminum alloys containing misch metal and beryllium to hot-dip coat fabricated steel parts has resulted in making aluminum-coated steel acceptable in certain fields from which it would have been excluded otherwise. The excellent resistance to corrosion in a moist atmosphere possessed by aluminum-coated steel is not seriously affected by these additions. Unfortunately, the additions are rather expensive, with misch metal costing $4.50 per lb. Nevertheless, the advantages to be gained from these additions are such that in many cases they outweigh the added cost.

Acknowledgment

The authors thank the Houdaille-Hershey Corp. and Mr. W. L. Pinner, Director of Research of that Corporation, for permission to publish this work.

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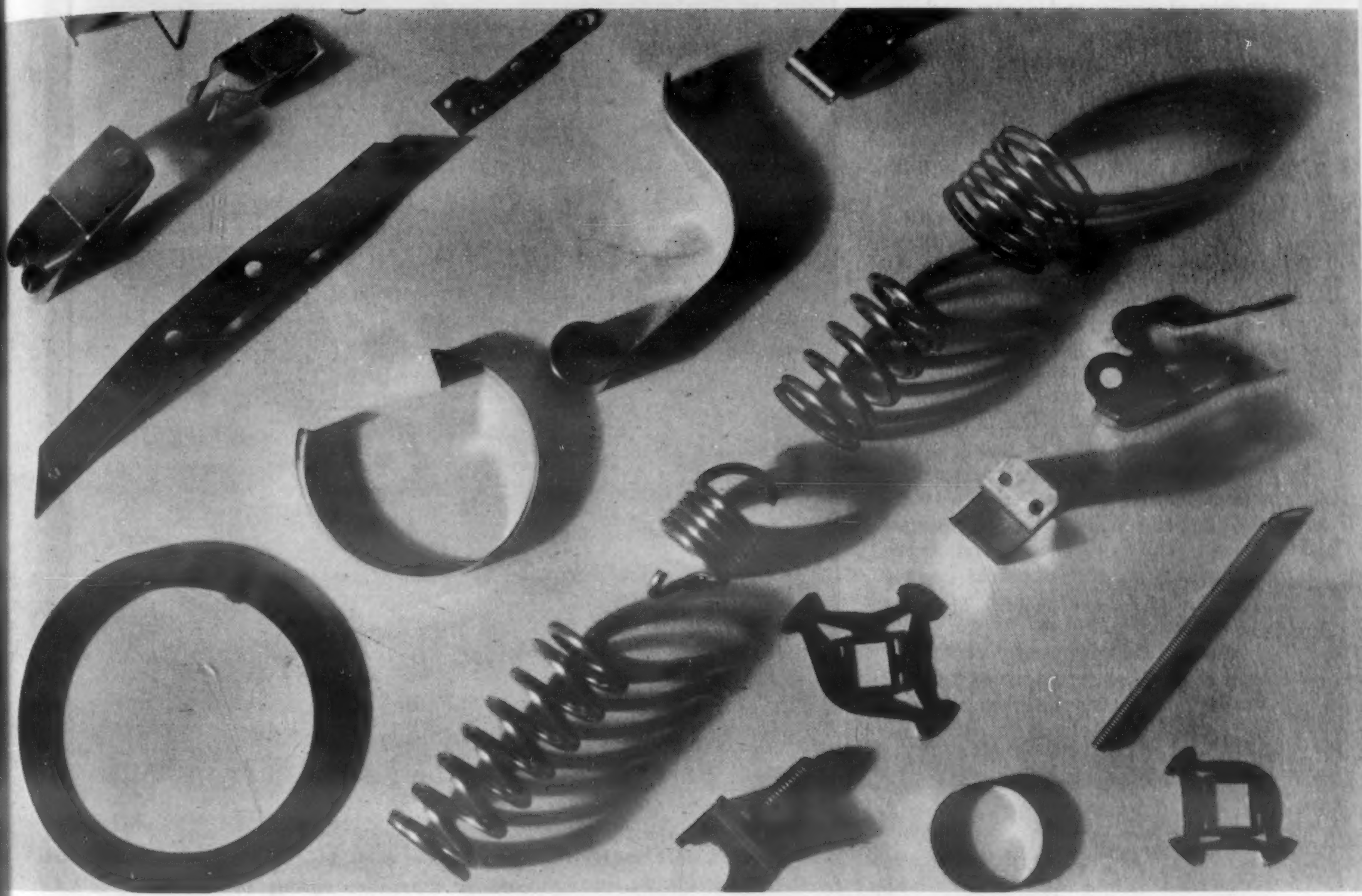


A few of the many styles of springs produced from phosphor bronze. (Seymour Manufacturing Co.)

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application.

The Wrought Phosphor Bronzes

by John L. Everhart, Associate Editor, Materials & Methods

The high elastic properties, excellent resistance to corrosion fatigue, and good electrical conductivities of the phosphor bronzes are responsible for the specialized applications of these alloys. They are used widely as springs, diaphragms, screens, machine parts, and in similar applications. In order to aid in the proper selection and use of phosphor bronzes, this manual presents information on the following points:

- **Standard Grades and Available Forms**
- **Engineering Properties**
- **Forming and Fabricating**
- **Joining Practice**
- **Surface Finishing**
- **Applications**

Introduction

Oldest of all alloys, bronze has been serving mankind continuously since prehistoric times in a wide variety of useful and ornamental applications. Its excellent properties made bronze a symbol of quality in the ancient world, and the metal is highly regarded today. Because it connotes quality, the term "bronze" has been applied to many copper-base alloys with little regard for the original usage or for the composition of the material. However, "bronze" referred originally to alloys of copper and tin.

The value of phosphorus as a deoxidizing agent for the tin bronzes was discovered about a century ago, and within 20 years this discovery was commercialized. The deoxidized alloys were found to be stronger and tougher than similar copper-tin alloys which had not been treated with phosphorus. Although the residual phosphorus content was frequently negligible, the alloys became known as *phosphor bronze,* a term which is used today.

Intense rivalry among producers resulted in the development of numerous proprietary phosphor bronzes, and considerable confusion still exists. In current commercial usage, phosphor bronzes are generally limited to those bronzes which have a phosphorus content of not less than 0.03%. However, there is an exception to this rule in the wrought alloy known as Grade E. In this alloy, the residual phosphorus content is intentionally very low in order to obtain the highest possible electrical conductivity. Standardization has led to simplification and in the wrought alloy field, today, a few alloys account for the major commercial tonnage of the phosphor bronzes.

In the cast alloy field, usage varies with the organization sponsoring the alloy. Thus, in one group an alloy may be designated "phosphor bronze" while in another, the same alloy may be called "tin bronze". Because of the differences in composition, properties and applications of the wrought and cast alloys, they fall naturally into two distinct groups. This manual is restricted to the wrought phosphor bronzes. Quite a number of alloys might be so classified, but for simplicity the discussion is confined to the alloys shown in the accompanying table, which are in most common use.

Normally the tin content of the wrought phosphor bronzes ranges from 5 to 10%, although for special purposes, alloys containing as little as 1% of tin are employed. The excellent cold-working properties of these bronzes introduce difficulties in machining since considerable elastic deformation occurs before the shearing of the chip. If improved machining properties are required, lead is added. The lead does not alloy with the bronze but is distributed throughout in the form of isolated particles which act as chip breakers and permit higher speed machining. A special phosphor bronze containing lead and zinc in addition to tin has been developed for the production of screw-machine products. This alloy can be machined as readily as free-cutting brass. The residual phosphorus content of the wrought alloys ranges in general, from 0.03 to 0.50%. Since the role of phosphorus is that of a purifier and deoxidizer, the element is usually ignored in quoting the composition.

Operating in a moist atmosphere at 350 F, these guide fingers of Grade A phosphor bronze transfer paper from one roll to another in a paper-corrugating machine. (Riverside Metal Co.)

Although there are few industries which do not use phosphor bronze in some form, little publicity has been given to these alloys. No spectacular bridges, boats or buildings are built of phosphor bronze. Their functions are less striking but no less necessary. To a great extent the phosphor bronzes furnish the electrical contact springs which contribute to the transmission of light and power, to modern communication by telephone, telegraph and radio, and to the control of electronic instruments. Modern paper-making depends on fourdrinier screens produced from phosphor bronze. The mining industry would be seriously handicapped if it were not for the phosphor bronze rifle nut which stands up under the severe punishment given it during the operation of compressed air machinery. These are all essential functions but are not the type which make the headlines.

Standard Grades and Available Forms

As a group, the phosphor bronzes have a number of highly useful properties. They are tough and strong, and are quite readily formed. One of their outstanding characteristics is high resistance to alternating stresses. They have low coefficients of friction in contact with most other metals. They are good electrical and thermal conductors. Their resistance to corrosion compares favorably with that of copper and they are generally not susceptible to season-cracking. They are nonmagnetic and spark resistant.

The alloys included in Table 1 are standard alloys sponsored by the Copper and Brass Research Assn. and comprise those which account for the major tonnage of the phosphor bronzes. Applicable ASTM specifications are given in Table 2. The materials engineer concerned with the applications of the phosphor bronzes should become familiar with the standards of the Copper and Brass Research Assn. and those of the ASTM, for they contain much useful information. Thus, temper designations for flat products and wire are given in the appropriate ASTM standard, and the mills generally use these values in defining the hardness of the material.

The general purpose alloy is Grade A containing 5% tin. This alloy combines high strength and toughness with excellent resistance to fatigue and good ductility. By virtue of these properties, Grade A is used widely in the manufacture of mechanical and current-carrying springs, electrical contacts, diaphragms, bellows, bridge bearing plates, Bourdon tubing, and welding rods.

Although Grade A is satisfactory for the majority of uses, there are special applications where a higher strength or increased formability for a given strength are required. For such applications, Grade C containing 8% tin may be employed. This alloy is used in applications similar to those cited for Grade A, for fourdrinier wire, high strength springs, gears and pinions, and sleeve bushings.

Grade D, containing 10% tin, has the highest strength and formability of all the wrought phosphor bronzes. It is used for rifle nuts for compressed air drilling equipment, beater bars, bearing plates, gears and pinions, and high strength springs.

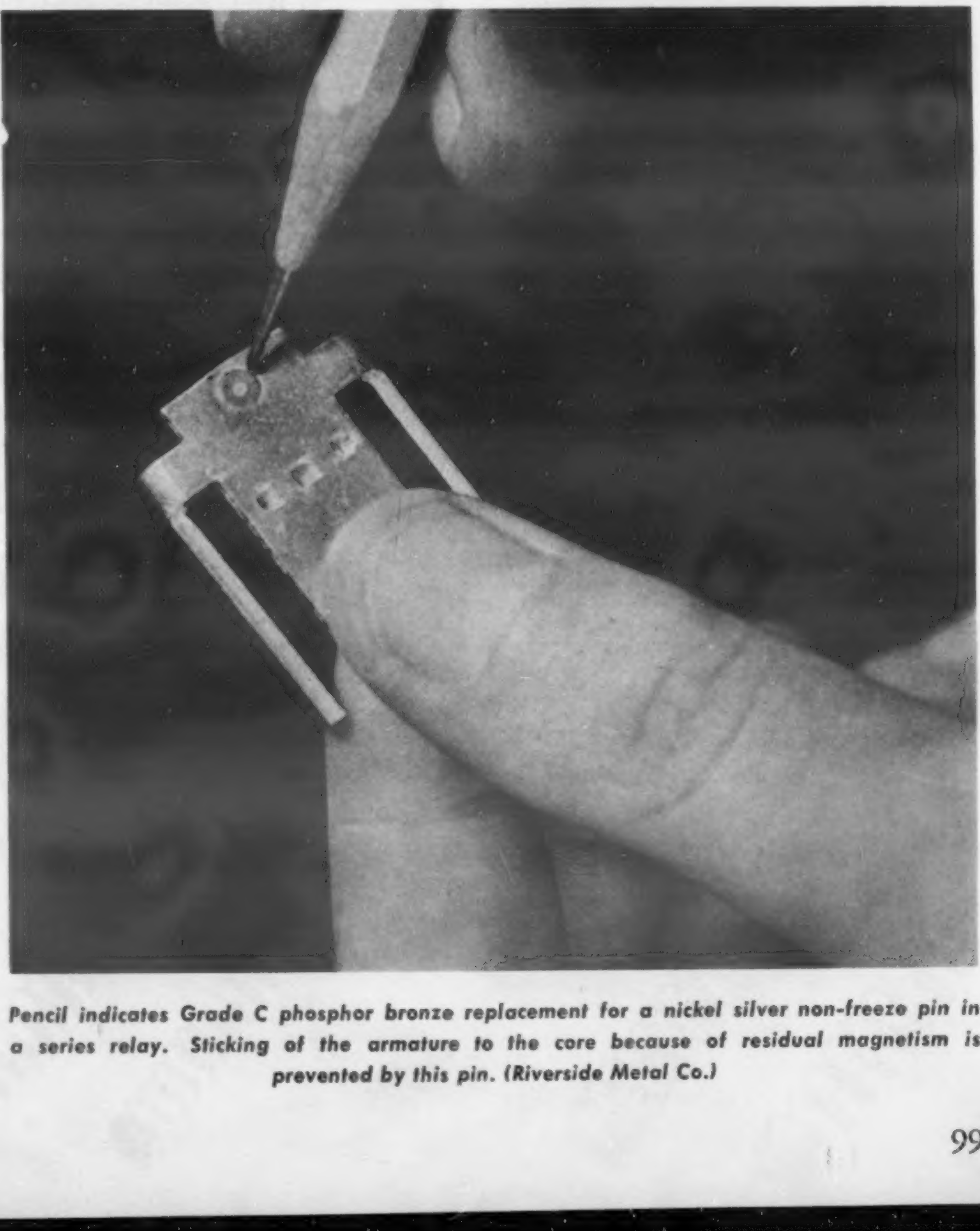
Grade E, containing 1.25% tin,

Table 1—Nominal Compositions of Wrought Phosphor Bronzes

Designation	Composition, %				
	Tin	Lead	Zinc	Phosphorus	Copper
Phosphor Bronze, 5% (A)	5	..	..	0.25	Balance
Phosphor Bronze, 8% (C)	8	..	..	0.25	Balance
Phosphor Bronze, 10% (D)	10	..	..	0.25	Balance
Phosphor Bronze, 1.25% (E)	1.25	..	..	Trace	Balance
Leaded Phosphor Bronze, 5% (B1)	5	1	..	0.25	Balance
Special Free-Machining Phosphor Bronze 444 (B2)	4	4	4	0.25	Balance

Table 2—Nearest Applicable ASTM Specifications

Designation	Rolled Flat Products	Drawn Flat Products	Rod	Wire
Phosphor Bronze, 5% (A)	B103-A	B139-A	B139-A	B159-A
Phosphor Bronze, 8% (C)	B103-C	B139-C	B139-C	B159-C
Phosphor Bronze, 10% (D)	B103-D	B139-D	B139-D	B159-D
Phosphor Bronze, 1.25% (E)	....	....	....	....
Leaded Phosphor Bronze, 5% (B1)	B103-B1	B139-B1	B139-B1	....
Special Free-Machining Phosphor Bronze 444 (B2)	....	B139-B2	B139-B2	....



Pencil indicates Grade C phosphor bronze replacement for a nickel silver non-freeze pin in a series relay. Sticking of the armature to the core because of residual magnetism is prevented by this pin. (Riverside Metal Co.)

has the highest electrical conductivity of the standard alloys and is used frequently where this property is important. The strength of the alloy is rather low and, in consequence, it is employed where strength requirements are not severe, particularly in such applications as high-conductivity light-duty springs, electrical contacts, pole-line hardware, and signal wire. The alloy may be hot formed and is frequently used for the purpose.

Grade B1, containing 5 tin and 1% lead, has good strength and ductility, and is more readily machinable than the alloys which contain no lead, although its machinability is only half as good as free-cutting brass. Grade B1 is used for various formed parts, bushings, gears and screw machine products.

Grade B2, containing 4 tin, 4 lead, and 4% zinc, is a special purpose bronze with machinability practically equal to that of free-cutting brass. It is used widely for screw machine products, bearings, gears, and in similar applications.

The combined tonnage of the six alloys just described accounts for more than 90% of the wrought phosphor bronze used commercially. There are a number of other alloys available which are, in general, modifications of the group. These alloys are in less general usage than those given in Table 1 and their properties have not been included in this manual.

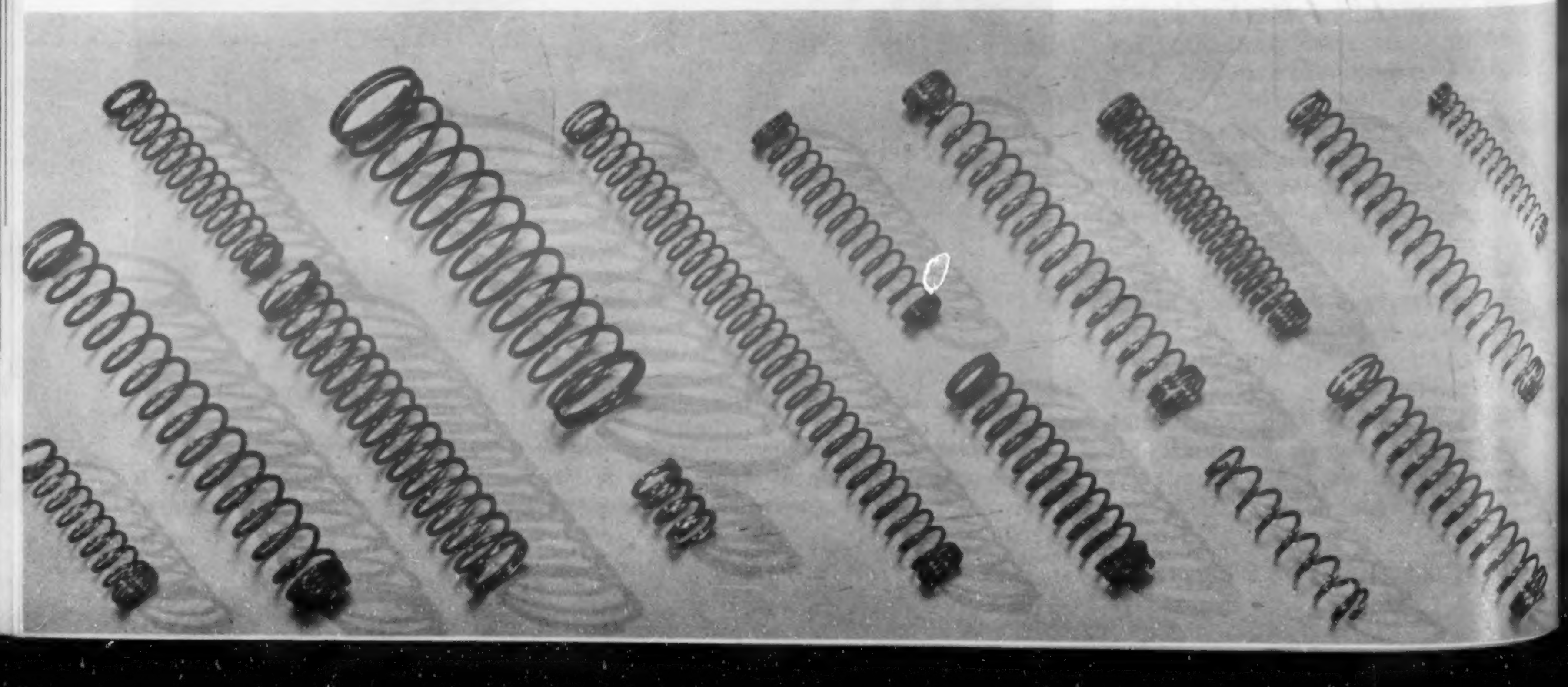
The most commonly used forms and tempers are given in Table 3. The term "temper" is sometimes confusing. Thus, to temper means to soften, as in the heat treatment of steel, but temper when used as a noun in connection with copper alloys, indicates the hardness. It is usually denoted by the terms "soft", "hard", "spring", and so on, each of which indicates a definite amount of cold-working at the mill before shipment. Although in the past it was customary to define temper in terms of B & S numbers, reduction by working this practice has generally been discarded and temper is now defined in terms of tensile strength. Standards of temper in terms of strength have been established by the ASTM and are in general use.

Table 3—Forms and Tempers Most Commonly Used

	Phosphor Bronze, 5% (A)	Phosphor Bronze, 8% (C)	Phosphor Bronze, 10% (D)	Phosphor Bronze, 1.25% (E)
STRIP, ROLLED				
Annealed (0.025 mm)	..	..	..	X
Half Hard	X	X	X	X
Hard	X	X	X	X
Extra Hard	X	X	X	..
Spring	X	X	X	X
Extra Spring	X	X	X	..
FLAT WIRE, ROLLED				
Spring	X	..	..	..
ROD				
Half Hard	X	X	X	..
WIRE				
Eighth Hard	X	..	..	..
Quarter Hard	X	X	X	..
Half Hard	X	X	X	..
Hard	X	X	X	X
Extra Hard	X	X	..	..
Spring	X	..	..	..
TUBE				
Hard Drawn	X	..	..	..

More phosphor bronze is produced in wire form than in any other shape. Wire may include material up to ½ in. in dia since wire and rod sizes overlap. In the terminology of the industry, material other than flat products or tubing furnished in coils is termed wire while that furnished straight may be called rod or shape. Of the wire produced, more than 90% consists of Grade A, with most of this in spring temper. Grade C and D account for about 5% of the production. A considerable quantity of Grade C wire in annealed temper is used for the production of fourdrinier screens. In the form of flat products, Grade A in spring temper is most widely used. Grades B1 and B2 account for most of the rod production, followed by Grade D, which is used extensively in this form for rifle nuts in particular and for other machine parts. Although tubing is not used to any great extent, it has a number of potential uses in the electronics industry which indicate that the demand for this form will increase.

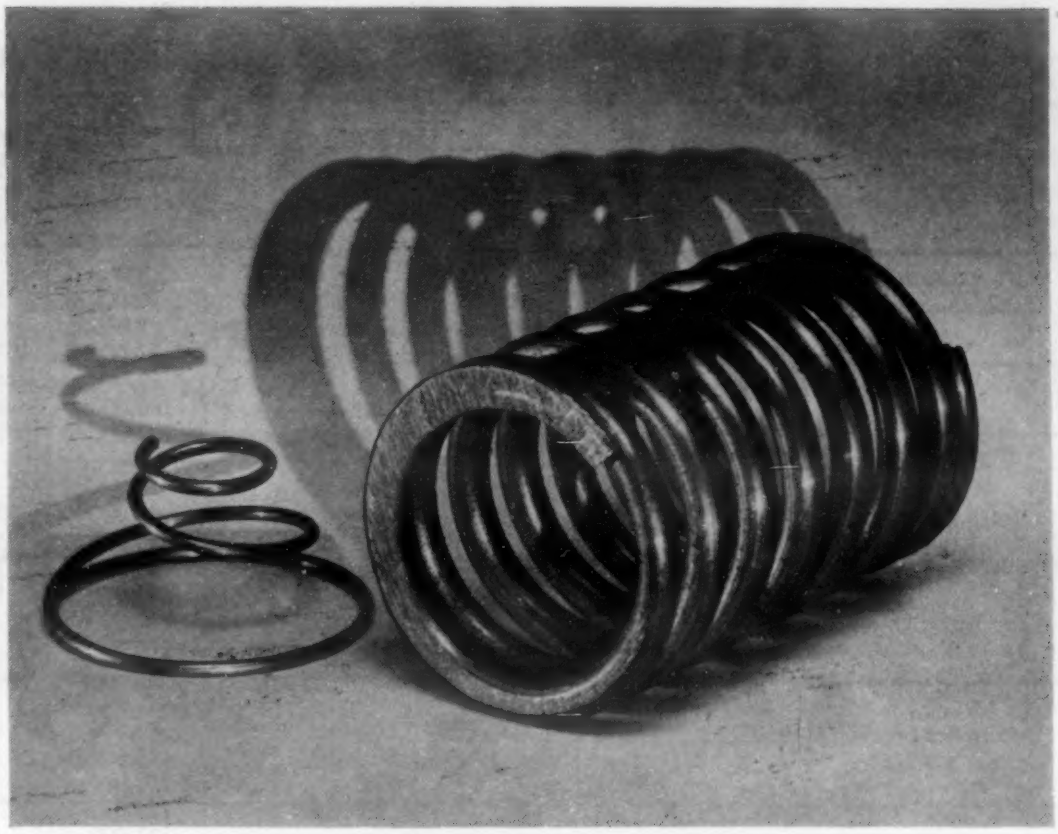
Phosphor bronze coil springs are used in many applications. (Scovill Manufacturing Co.)



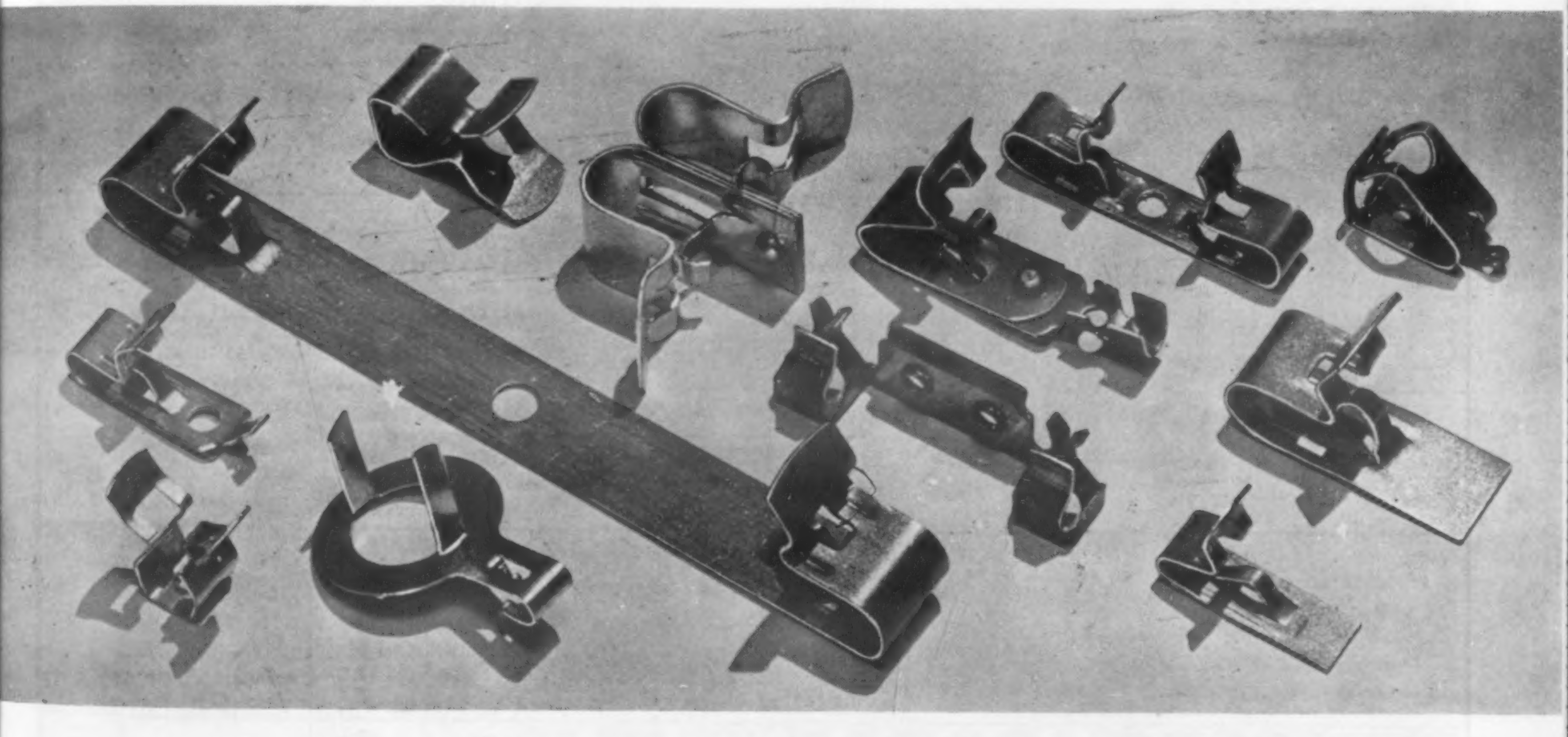
Engineering Properties

Physical Properties

The more useful physical properties of the phosphor bronzes are given in Table 4. These alloys have relatively broad freezing ranges and require special care for the production of sound castings suitable for fabrication. The densities, coefficients of thermal expansion and moduli of elasticity are quite close to those of copper. The alloys have relatively good electrical and thermal properties. Although the electrical conductivities appear low in relation to copper, phosphor bronzes have the highest conductivities for equal strength of any of the nonprecipitation hardening copper alloys. Many of the applications of phosphor bronzes are based on their good electrical properties.



Large phosphor bronze compression springs. (Scovill Manufacturing Co.)



Phosphor bronze spring clips serve the electrical and communications industries. (Scovill Manufacturing Co.)

Table 4—Typical Physical Properties

Designation	Melting Range		Density Lb/Cu In. at 68 F	Specific Gravity	Coef of Ther. Exp. per °F 68–572 F	Ther. Cond. Btu/Sq Ft/Ft/Hr/F at 68 F	Elec. Cond. % I.A.C.S. at 68 F	Capacity Btu/Lb/°F at 68 F	Mod. of Elast. (Ten.), Psi
	Liquidus, F	Solidus, F							
Phosphor Bronze, 5% (A)	1920	1750	0.320	8.86	9.9×10^{-6}	47	18	0.09	16,000,000
Phosphor Bronze, 8% (C)	1880	1620	0.318	8.80	10.1×10^{-6}	36	13	0.09	16,000,000
Phosphor Bronze, 10% (D)	1830	1550	0.317	8.78	10.2×10^{-6}	29	11	0.09	16,000,000
Phosphor Bronze, 1.25% (E)	1970	1900	0.321	8.89	9.9×10^{-6}	120	48	0.09	17,000,000
Leaded Phosphor Bronze, 5% (B1)	1920	1750	0.322	8.91	9.9×10^{-6}	48	16	0.09	15,000,000
Special Free-Cutting Phosphor Bronze 444 (B2)	1830	1700	0.320	8.85	9.6×10^{-6}	47	12	0.09	15,000,000

Table 5—Typical Mechanical Properties

Designation	Section Size	Temper	Ten. Str., Psi	Yd. Str., ½% Extension under Load, Psi	Elong., % in 2 In.	Rockwell Hardness		
						F	B	30T
FLAT PRODUCTS								
Phosphor Bronze, 5% (A)	0.040 in.	0.035 mm[1]	49,000	20,000	58	75	28	..
		Half hard	68,000	55,000	28	..	78	69
		Hard	81,000	75,000	10	..	87	75
		Extra hard	92,000	80,000	6	..	93	78
		Spring	100,000	80,000	4	..	95	79
		Extra spring	107,000	80,000	3	..	97	80
Phosphor Bronze, 8% (C)	0.040 in.	0.025 mm[1]	60,000	24,000	63	82	50	..
		Half hard	76,000	55,000	32	..	84	73
		Hard	93,000	72,000	10	..	93	78
		Extra hard	106,000	80,000	4	..	96	80
		Spring	112,000	....	3	..	98	81
		Extra spring	120,000	....	2	..	100	82
Phosphor Bronze, 10% (D)	0.040 in.	0.035 mm[1]	66,000	28,000	68	..	55	..
		Half hard	83,000	....	32	..	92	..
		Hard	100,000	....	13	..	97	..
		Extra hard	115,000	....	7	..	100	..
		Spring	122,000	....	4	..	101	..
		Extra spring	128,000	....	3	..	103	..
Phosphor Bronze, 1.25% (E)	0.040 in.	0.025 mm[1]	40,000	14,000	48	60	..	..
		Half hard	55,000	....	16	..	64	60
		Hard	65,000	50,000	8	..	75	67
		Spring	75,000	....	4	..	79	70
Special Free-Cutting Phosphor Bronze 444 (B2)	0.040 in.	0.035 mm[1]	45,000	23,000	55	65	-14	..
	0.040 in.	Half hard	58,000	40,000	24	96	68	..
ROD								
Phosphor Bronze, 5% (A)	0.500 in.	Half hard (20%)	75,000	65,000	25	..	B80	..
	1.0 in.	Half hard (20%)	70,000	58,000	25	..	B78	..
Phosphor Bronze, 8% (C)	0.500 in.	Half hard (20%)	80,000	65,000	33	..	B85	..
Phosphor Bronze, 10% (D)	1.0 in.	Hard	85,000	....	25	..	..	..
Leaded Phosphor Bronze, 5% (B1)	1.0 in.	Hard (20%)	70,000	58,000	25	..	B78	..
Special Free-Cutting Phosphor Bronze 444 (B2)	0.5 in.	Hard (35%)	75,000	63,000	15	..	B83	..
	1.0 in.	Hard (25%)	68,000	57,000	20	..	B80	..
	2.0 in.	Hard (20%)	63,000	55,000	30	..	B80	..
WIRE								
Phosphor Bronze, 5% (A)	0.080 in.	0.035 mm[1]	50,000	20,000	58	..	..	..
		Quarter hard	68,000	60,000	24	..	..	..
		Half hard	85,000	80,000	8	..	..	..
		Hard	110,000	....	5	..	..	..
		Extra hard (75%)	130,000	....	3	..	..	..
		Spring (84%)	140,000	....	2	..	..	..
Phosphor Bronze, 8% (C)	0.080 in.	0.035 mm[1]	60,000	24,000	65	..	..	..
		Quarter hard	81,000	....	..	..	..	..
		Half hard	105,000	....	..	..	..	..
		Hard	130,000	....	..	..	..	..
		Extra hard	140,000	....	..	..	..	..
Phosphor Bronze, 10% (D)	0.080 in.	0.035 mm[1]	66,000	....	70	..	..	..
		Quarter hard	93,000	....	..	..	..	..
		Half hard	118,000	....	..	..	..	..
		Hard	147,000	....	..	..	..	..
Phosphor Bronze, 1.25% (E)	0.080 in.	Hard (80%)	79,000	....	1*	..	..	..
	0.460 in.	Hard (70%)	72,000	....	4*	..	..	..

** Elongation in 10 in.*

[1] Annealed to grain size indicated.

Mechanical Properties

Typical mechanical properties of phosphor bronzes in the form of flat products, rod and wire are given in Table 5. The effects of cold work on the strength of the alloys is clearly indicated in these tables. The ductility is reduced drastically by severe cold-working, an effect which is very important in connection with subsequent forming of the alloys, since it is a limiting factor in the selection of the temper to be used in fabricating the materials. The high elastic properties of the phosphor bronzes are among their outstanding characteristics. It has been stated by one authority that elastic limits within 90% of the tensile strength can be obtained with phosphor bronze wire. These superior elastic properties make the alloys unsurpassed for applications where spring properties are the most important consideration. Increasing the tin and phosphorus content results in an increase in the strength of the alloys. Thus, Grade A phosphor bronze in spring temper has a tensile strength of 100,000 psi, while Grade D in the same temper has a strength of 122,000 psi.

Elevated Temperature Properties

The phosphor bronzes are not generally considered suitable for elevated temperature service, since strength and ductility decrease rapidly with increasing temperatures. For springs and similar applications in which the part is stressed by external loading, operating temperatures are limited because a constantly deflected spring undergoes relaxation or loss of load with time. Thus, design stresses for springs should be reduced by 20% at 200 F and by 40% at 300 F for hard temper phosphor bronze if elevated temperature service is required of the alloy. However, the maximum service temperature generally recommended for phosphor bronze is 200 to 225 F.

Low Temperature Properties

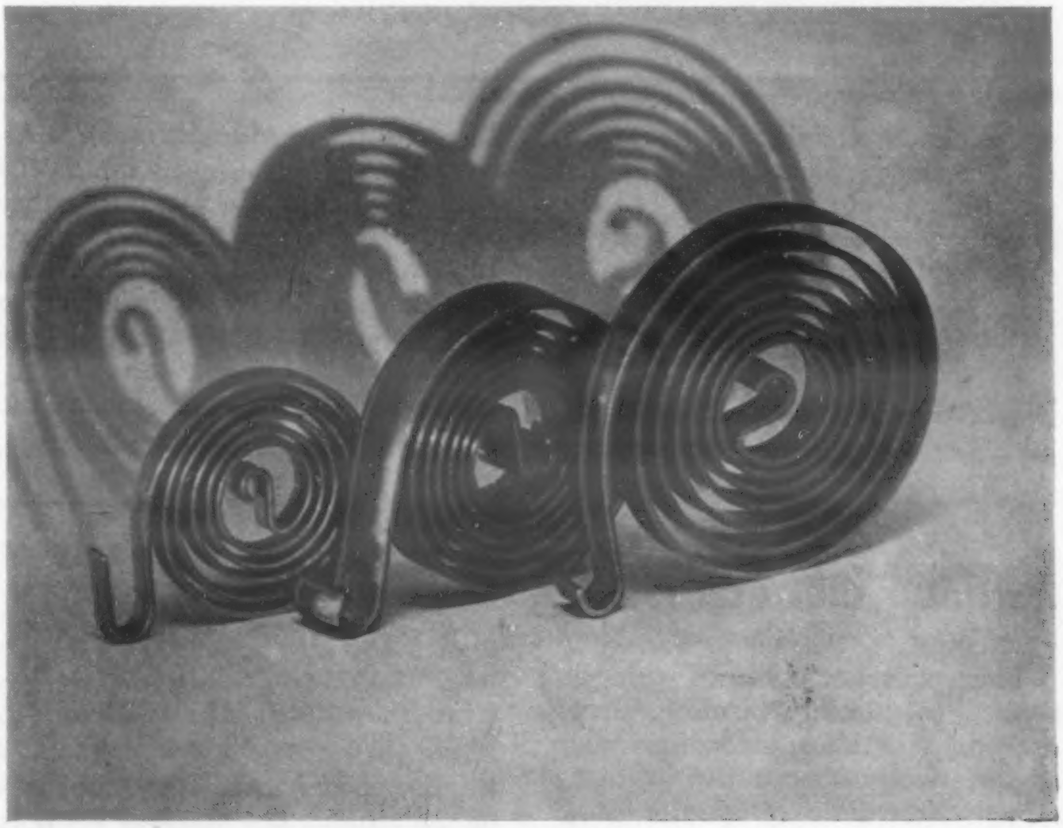
Like all alpha solid solution copper alloys, the phosphor bronzes retain their ductility at low temperatures. There is no significant change in the tensile strength or the impact strength as the temperature is lowered while the modulus of elasticity tends to increase slightly. The increase in the modulus causes springs to become stiffer at low temperatures. The phosphor bronzes are well suited for low-temperature applications and are employed in refrigeration and in high altitude service, as in aircraft instruments.

Table 6—Typical Endurance Properties

Designation	Form	Section Size	Temper	Endurance Strength Psi	Endurance Strength Cycles
Phosphor Bronze, 5% (A)	Flat products	0.040 in.	Hard	25,000	10^8
	Flat products	0.040 in.	Spring	22,000	10^8
	Wire	0.080 in.	Hard	27,000	10^8
	Wire	0.080 in.	Extra hard (75%)	30,000	10^8
Phosphor Bronze, 8% (C)	Flat products	0.040 in.	Hard	22,000	10^8
Phosphor Bronze, 1.25% (E)	Wire	0.080 in.	Hard (80%)	32,000	10^8

Table 7—Corrosion Fatigue Strength

Designation	Endurance Limit Air, Psi	Corrosion Fatigue Limit Salt Water, Psi	Cycles
Phosphor Bronze, 5% (A)	27,000	22,000	5×10^7
Phosphor Bronze, 10% (D)	17,000	17,000	10^7
Phosphor Bronze, 1.25% (E)	16,000	17,000	4×10^7



Spiral springs produced from flat wire are used in clocks and for similar applications. (Scovill Manufacturing Co.)

Fatigue and Corrosion Fatigue

Phosphor bronzes have very good resistance to alternating stress. Endurance strengths for several grades are given in Table 6. Although working stresses based on the endurance limit are considerably lower than those which can be handled with spring steel, the phosphor bronzes have a definite advantage over steel in their resistance to corrosion fatigue. Unlike spring steel, phosphor bronze loses very little strength when exposed to a combination of corrosive environment and cyclic stress. The effect of salt water on the endurance strength is given in Table 7 for several grades of phosphor bronze. In addition, the phosphor bronzes are not subject to the stress-corrosion cracking which limits the application of some of the brasses

Table 8—Approximate Corrosion Resistance of Phosphor Bronzes

Good	Fair	Poor
Acetic Acid	Ammonium Sulfate	Acetylene
Ammonia, Dry	Chlorine, Moist	Ammonia, Wet
Atmosphere, Rural, Industrial, Marine	Chloracetic Acid	Ammonium Hydroxide
Benzol	Copper Nitrate	Ammonium Chloride
Boric Acid	Ferrous Chloride	Ammonium Nitrate
Butane	Ferrous Sulfate	Chromic Acid
Carbon Dioxide	Hydrochloric Acid	Ferric Chloride
Chlorine, Dry	Hydrofluoric Acid	Ferric Sulfate
Citric Acid	Hydrogen Peroxide	Hydrocyanic Acid
Copper Sulfate	Phosphoric Acid	Hydrogen Sulfide, Moist
Hydrogen	Potassium Hydroxide	Mercury and Mercury Salts
Hydrogen Sulfide, Dry	Sodium Hydroxide	Nitric Acid
Natural Gas	Sodium Hypochlorite	Picric Acid
Potassium Chloride	Sodium Peroxide	Potassium Cyanide
Potassium Sulfate	Sodium Sulfide	Sodium Cyanide
Sodium Carbonate	Sodium Thiosulfate	Sulfur, Molten
Sodium Chloride	Sulfur, Solid	
Sodium Nitrate	Sulfuric Acid	
Sodium Sulfate	Water, Acid Mine	
Sulfur Dioxide	Zinc Chloride	
Sulfur Trioxide		
Water, Fresh or Sea		

Good indicates usable under most conditions.
Fair indicates subject to attack but may be used under certain conditions.
Poor indicates unsuitable.

under certain conditions. Resistance to corrosion fatigue is one of the outstanding characteristics of the phosphor bronzes and is the basis of many applications.

Corrosion Resistance

Phosphor bronzes are highly resistant to attack by the atmosphere and by both fresh and salt water. Although they are attacked rapidly by oxidizing acids, such as nitric, they resist attack by both dilute and concentrated sulfuric acid at room temperature and are fairly resistant to hydrochloric acid. In general, the organic acids are less corrosive toward phosphor bronze than the mineral acids.

Phosphor bronzes resist attack by both sodium and potassium hydroxides and most of the alkaline salts at moderate temperatures. However, these alloys are not suitable for use in contact with ammonium salts or ammonium hydroxide. Neutral salt solutions are, in general, not corrosive to phosphor bronze while the acid salts may hydrolize to form weak acids and attack the bronze.

Although phosphor bronzes are not attacked by dry ammonia, chlorine or hydrogen sulfide, they are attacked with varying degrees of severity if moisture is present in the gas. On the other hand, these alloys are resistant to carbon dioxide, sulfur dioxide and sulfur trioxide even in the presence of moisture.

Phosphor bronzes are considered to be immune to season-cracking. The leaded bronzes have corrosion properties similar to those of the nonleaded alloys.

Table 8 gives an estimate of the resistance of the phosphor bronzes to a number of corroding media. This table should be used as a preliminary guide to the suitability of the phosphor bronzes for use in a particular environment. Rates of corrosion are affected so greatly by such factors as purity of solution, aeration, flow of the liquid, temperature and other considerations that no specific recommendations are possible, and an actual test is desirable.

Forming and Fabricating

The phosphor bronzes can be formed by turning, bending, deep-drawing and similar operations with comparative ease since they have excellent cold-working properties. They are cold-formed at the mill by rolling or drawing, the desired temper being obtained by a suitable selection of the rolling or drawing schedule. Since these alloys, like all single-phase copper alloys, cannot be hardened by heat treatment, increases in strength can be obtained only by cold work. Cold-working imparts directional properties to the material which may have considerable influence on subsequent operations.

Although some mills are hot-forming phosphor bronzes containing as much as 4% tin, the alloys are not generally considered suitable for such treatment because of a narrow hot-working range. The single exception in this group is Grade E. This alloy, containing only 1.25% tin, has good hot working properties in the range 1450 to 1600 F. It is used extensively for components which may be hot-forged.

Heat Treatment

The principal objective of heat treatment is to anneal or soften the alloys for further cold-working, since these alloys cannot be hardened by heat treatment. Generally, the alloys are annealed in the temperature range

Table 9—Fabricating Properties

Designation	Cold Working	Hot Working	Hot Working Temp. Range, F	Annealing Temp. Range, F
Phosphor Bronze, 5% (A)	Excellent	Poor	....	900–1250
Phosphor Bronze, 8% (C)	Good	Poor	....	900–1250
Phosphor Bronze, 10% (D)	Good	Poor	....	900–1250
Phosphor Bronze, 1.25% (E)	Excellent	Good	1450–1600	900–1200
Leaded Phosphor Bronze, 5% (B1)	Fair	Poor	....	900–1250
Special Free-Cutting Phosphor Bronze 444 (B2)	Fair	Poor	....	900–1250

900 to 1250 F. However, a special low-temperature anneal is used for relief of residual stresses without unduly softening the cold-worked material. Temperatures of the order of 400 to 550 F are employed for this stress-relief anneal.

Fabricating

Because of the directional properties imparted during rolling, phosphor bronze in sheet or strip form can be bent more readily across the rolling direction than parallel to the rolling direction. This fact has caused many fabricating difficulties. With simple parts, it is possible to select a design in which the more drastic bends are made across the grain or on a diagonal, thus minimizing the differences in bending characteristics. However, in more complicated parts, it may not be possible to avoid making severe bends with the grain. Typical bending properties of several of the alloys are given in Table 10. These figures indicate that bends in strip can be made around much sharper radii across the grain than with the grain.

Bending difficulties may be overcome frequently by a change in grade or temper. For example, spring temper Grade A is the most widely used phosphor bronze in the form of sheet or strip. While it is possible to make a sharp bend across the grain in the lighter gages in spring temper, such a bend would cause cracking if made with the grain. Thus, it might be impossible to make a complicated part by bending Grade A strip in spring temper. If redesign of the part should be impractical, changing the temper or grade of the phosphor bronze might overcome the difficulty. Since formability is a function of the temper, changing from spring to hard temper would permit sharper bends with the grain. However, if Grade A were used, the strength would be reduced considerably. In order to retain the strength, Grade C could be substituted for Grade A. Hard temper Grade C has the same strength as spring temper Grade A but the formability is better since it has not been so drastically cold-worked. This example is cited merely to indicate the manner in which advantage can be taken of the variations in properties of the various grades and tempers. Since there is a right grade and temper for each application, the producer should be consulted if difficulty is experienced in bending the phosphor bronzes.

Table 10—Minimum Permissible Bending Radii for 0.020-In. Strip

Temper	Grade A		Grade C		Grade D	
	Hard	Spring	Hard	Spring	Hard	Spring
Across the Grain	Sharp	1/64 in.	Sharp	1/32 in.	1/32 in.	1/16 in.
With the Grain	1/16 in.	3/16 in.	1/16 in.	1/4 in.	7/32 in.	over 1/4 in.

Table 11—Suggestions for Machining the Nonleaded Phosphor Bronzes

Type of Tool	Tool Angles	Remarks
Turning Tools	Top rake angle, 8–12 deg Clearance angle, 5 deg	Lubricant-mineral oil containing 10–20% lard oil
Drills	Standard twist drills	Usually lubricated
Reamers	Standard fluted reamers with 7–8 deg helix angle and 5 deg hook angle	
Milling Cutters	Land clearance, peripheral teeth, 12–17 deg; side or end teeth, 2–6 deg; top rake, peripheral teeth, 10–20 deg; rake, side or end teeth, 2–3 deg	Angles given are for high-speed steel tools. For carbide tools, angles for peripheral teeth should be reduced.
Radial Thread Chasers	Face angle, 1½ deg; top rake angle, 20 deg; clearance angle, 12 deg	Lubricant-paraffin oil

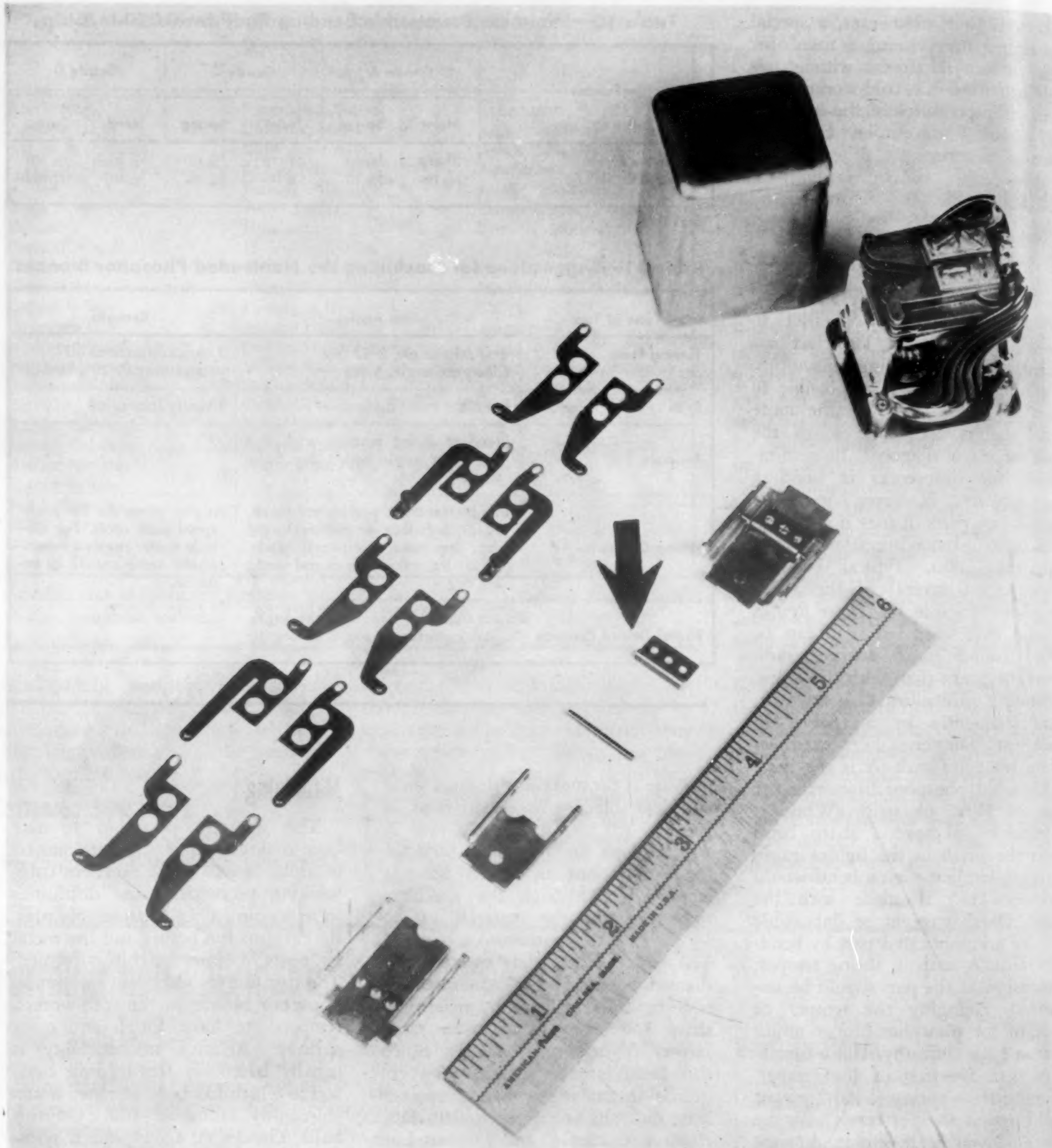
Wire is far more ductile than sheet and less difficulty is experienced in forming it. Spring temper Grade A wire is used for more than 90% of the applications in which wire is employed. Although the specifications call for the material up to 1/4 in. in dia to withstand a bend of 120 deg., on a radius equal to its diameter, most of the manufacturers test the coils of wire by making a sharp 360-deg bend to insure satisfactory fabricating properties. Since this bend is more drastic than required in making a helical spring, little difficulty is experienced in fabrication. Grades C and D phosphor bronze are used for only about 5% of the wire applications.

The phosphor bronzes can be stamped, formed and deep-drawn readily with the same tools which are used for cold-rolled steel of the same thickness. Adequate lubrication is required to prevent the formation of tin compounds which can be quite abrasive to the tools and dies. Adaptability for spinning can be indicated on a comparative basis. If annealed commercial aluminum be given a rating of 100, soft temper Grade A phosphor bronze will have a rating of 74 for shallow spinning and 40 for deep spinning.

Machining

The wrought phosphor bronzes have a single phase structure similar to alpha brass. Their excellent cold-working properties cause difficulties in machining since considerable plastic deformation occurs and the metal is "upset" before the chip is formed. The turnings produced in machining phosphor bronze in the cold-worked tempers are long, tough and quite springy. Relative machinability is usually based on free-turning brass rod to which has been assigned a machinability rating of 100. On this basis, Grades A, C, D and E phosphor bronze have a rating of 20, classifying them with the alloys which are machinable with difficulty. However, these difficulties can be minimized by a proper choice of tools, lubricants and speeds.

Turning tools, for example, may have rake angles of 8 to 12 deg. and clearance angles of 5 deg. Since the long curling chip formed in cutting these materials has a tendency to weld to the tool, a cutting fluid is required which lubricates effectively as well as cools the work. A mineral oil containing from 10 to 20% lard oil is used frequently. Speeds as high as are consistent with surface



Grade C phosphor bronze contact springs (left) for a series relay similar to that shown at the top. The arrow indicates a phosphor bronze hinge-pin retainer which holds a stainless steel pin true to within 0.001 in. under shock loads up to 2000 ft-lb. (Riverside Metal Co.)

quality are employed with light feeds and moderate depths of cut. Generally, either high-speed steel or carbide tools are used in the machining of phosphor bronze. Choice of the type of tool is based on the service requirements. High speed steel tools are used for short runs while the carbide tools are used for long runs at high cutting rates.

The cold worked tempers are the most suitable for milling, shaping, planing, threading and machining operations in general. However, the presence of internal stresses may cause distortion upon machining. In a cold drawn rod, the outer layers are in tension while the center is in compression. Unsymmetrical cutting can result in distortion while removal of the outer layers may result in appreciable lengthening of the rod. In a similar manner, distortion might occur in the milling of a cold-worked flat product. The tendency toward distortion will be minimized by a low temperature anneal at 400 to 550 F. Such an anneal reduces residual stresses without appreciably affecting the strength of the bronze.

To meet the requirements of greater ease of machining for screw-machine products and the like, the phosphor bronzes are modified by the addition of lead. The lead does not enter into solid solution in the bronze

but occurs as fine particles dispersed throughout the material. These particles act as chip breakers with the result that short chips are formed instead of continuous chips, which are characteristic of the nonleaded alloys. One of the more generally used of the leaded phosphor bronzes is Grade B1. This alloy has a machinability rating of 50. It should be noted that Grade B1, while having considerably better machinability than nonleaded phosphor bronzes, is still only half as machinable as free-cutting brass and, therefore, cannot be expected to have machining properties equivalent to the latter, a point which is frequently overlooked. In order to meet higher machinability requirements, the special free-machining alloy known as Grade B2 or 444 was developed. This alloy is machined as readily as free-cutting brass.

In the leaded phosphor bronzes, the chip breaks rapidly and is in contact with the tool for a very short time. Rake angles and clearances on the tools can be held to a minimum. In machining these alloys, little lubrication is required of the cutting fluid, its function being almost entirely cooling. Low viscosity mineral oils or soluble oils can be used as the cutting fluids. The speed of machining may be as high as practicable. However, chatter is more severe with leaded than with nonleaded alloys, and greater rigidity of the machine assembly is required.

Joining Practice

Phosphor bronzes are readily joined to each other and to most other metals by soft soldering or by silver alloy brazing. The nonleaded alloys can be welded by most of the established welding practices but the carbon-arc, metal-arc and resistance methods are generally employed. Although phosphor bronzes can be joined by gas welding, particularly with the oxyacetylene flame, such methods are in less common use than electric welding methods. The production of satisfactory welds with leaded phosphor bronzes is difficult, and these alloys are not generally welded. The relative ease of joining the alloys by soldering and welding is indicated in Table 12.

For the production of satisfactory joints by any of the processes, clean surfaces are necessary. Surfaces should be free from dirt, grease and oil. Scale and oxide must be removed from the joint area for maximum joint strength.

Soldering and Brazing

The joining of metals by the use of nonferrous filler metal without fusion of the base metal is called soldering or brazing. Commonly, soldering refers to the use of the soft solders with melting points generally below 700 F. Brazing refers to the use of the hard solders which melt above 1100 F. Phosphor bronzes can be joined either with soft solders or with silver alloy brazing materials. The choice of an alloy for soldering or brazing depends on such factors as cost, strength and ductility required in the joint, operating temperature of the part, corrosion resistance required and, for some applications, color of the filler metal.

Similar methods are used in both processes, the variations being those necessitated by the differences in melting points of the solders or brazing alloys. Joints are generally made by flowing the molten solder between closely fitted surfaces, as in the common lapped joint.

Heating of the parts for soft soldering is accomplished with a torch, a soldering iron, or an oven; for brazing a torch, a gas-fired furnace or an electric furnace is used.

The ordinary lead-tin solders are satisfactory for soldering phosphor bronzes providing acid fluxes or proprietary fluxes recommended for the purpose are used. Since acid fluxes are corrosive, the residue should be removed after soldering by washing the part with dilute hydrochloric acid. For applications in which it is impossible to clean the joint after soldering, phosphor bronzes can be pretinned. Joints can then be produced with rosin or other noncorrosive fluxes.

For stronger joints than those obtainable with soft solders or for applications at elevated temperatures, assemblies can be brazed with the usual silver brazing alloys. Proprietary fluxes which are fluid at 1100 F are generally used. Since the

Table 12—Suitability of Joining Methods

Material	Soft Soldering	Silver Alloy Brazing	Carbon-Arc Welding	Metal-Arc Welding	Resistance Welding	Oxy-acetylene Welding
Grade A	Excellent	Good	Good	Good	Good	Good
Grade C	Excellent	Good	Good	Good	Excellent	Good
Grade D	Excellent	Good	Good	Good	Excellent	Good
Grade E	Excellent	Excellent	Good	Good	Fair	Good
Grade B1	Excellent	Good	Poor	Poor	Poor	Poor
Grade B2	Excellent	Good	Poor	Poor	Poor	Poor

Table 13—Some Silver Alloys Suitable for Brazing Phosphor Bronze

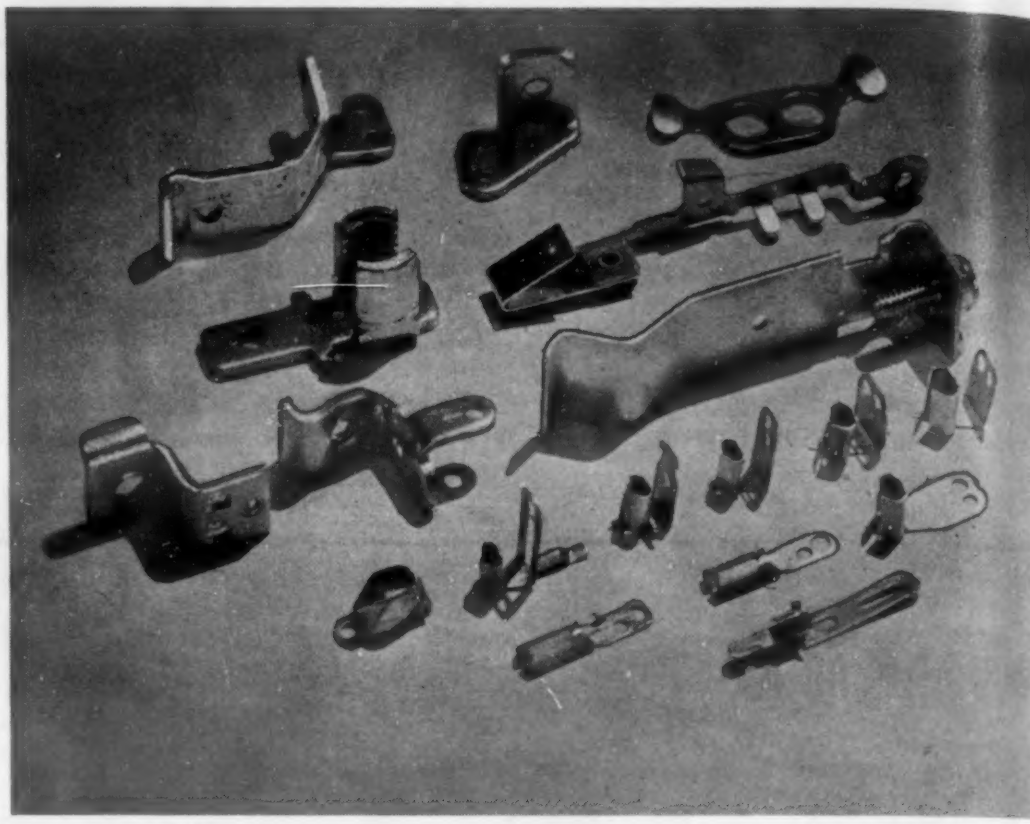
ASTM Grade	Silver	Copper	Zinc	Other	Flow Temperature, F
4	45	30	25	......	1370
5	50	34	16	......	1425
6	65	20	15	......	1390
7	70	20	15	......	1390
8	80	16	4	......	1460
(a)	15	80	..	5 phosphorus	1300
(a)	50	15.5	16.5	18 cadmium	1175

(a) *Proprietary.*

brazing temperatures are within the annealing range for phosphor bronze, joints should be made as rapidly as possible to avoid undue softening of the material. Brazing speed may be increased by the use of pre-brazed phosphor bronze, which is a recent development.

Carbon-Arc Welding

Phosphor bronzes are welded readily by the carbon-arc method. Direct current is used and the work is usually positive. Uncoated welding rods with a considerably higher phosphorus content than the base metal are used to compensate for losses due to vaporization of phosphorus under the high temperature of the carbon arc. A moderately long arc on the filler metal is recommended to produce the most satisfactory welds.



Various small parts are formed from phosphor bronze strip. (Scovill Manufacturing Co.)

Metal-Arc Welding

Metallic-arc welding is probably the most suitable method of welding phosphor bronzes. In this method a coated phosphor bronze welding rod is used as one electrode, the work being the other, and the rate of deposition of the weld metal is dependent on the current used. Although thin stock can be welded without preheating, it is desirable to preheat heavier gages to a temperature of 300 to 400 F to increase weld soundness. Preheating to the lowest possible temperature consistent with the formation of good welds is desirable to insure the rapid cooling necessary to prevent cracking. If the preheating temperature is too high, the welds may show excessive porosity. A similar effect might occur if the filler metal is deposited at too high a temperature. For maximum strength and ductility, the deposit is peened at temperatures of the order of 900 F after welding.

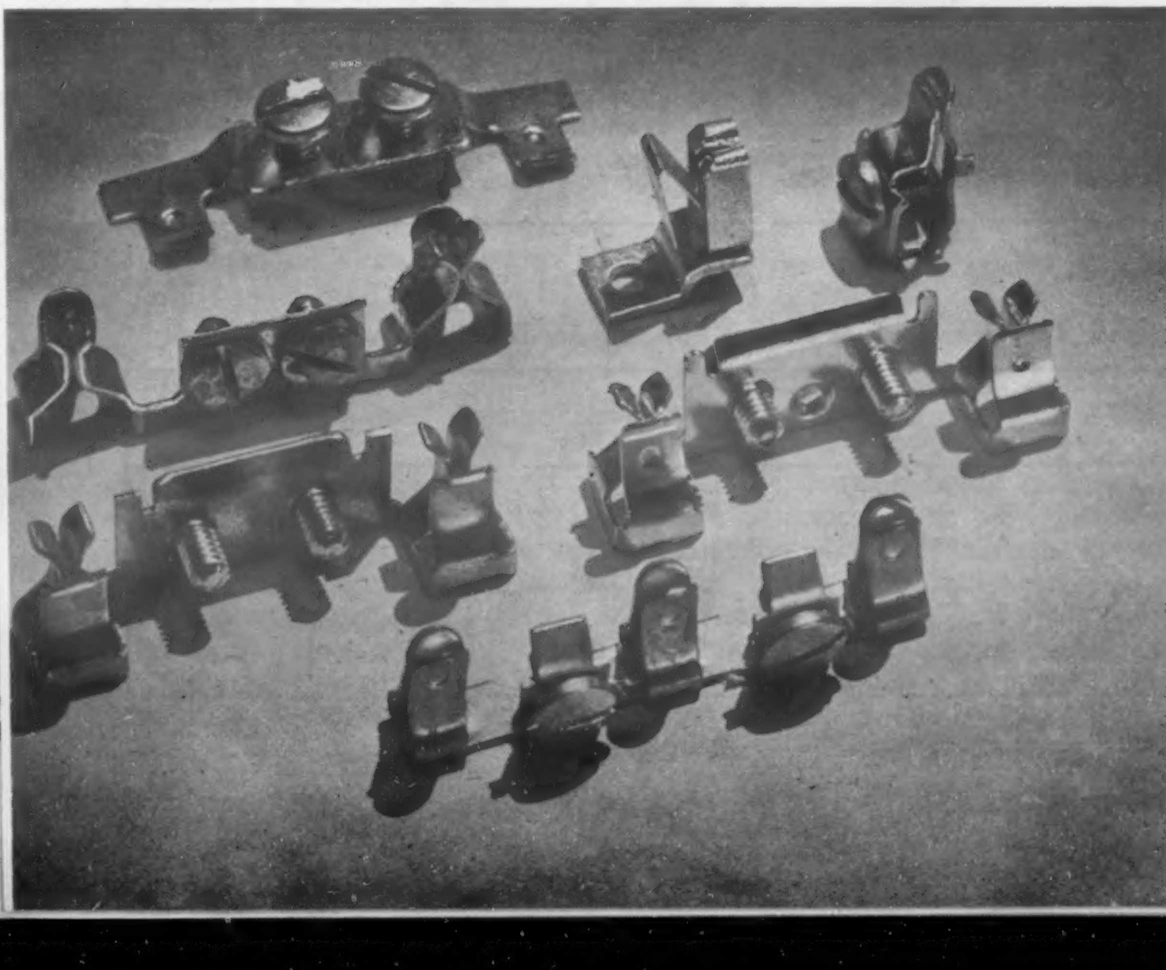
Resistance Welding

Resistance welding of phosphor bronzes is increasing in popularity. Because of the good conductivities of these alloys, welding machines must have sufficient electrical capacity to complete the weld in a minimum time interval. Long heating periods result in the heating of too large an area with excessive oxidation and the possibility of distortion of the material. Phosphor bronzes are resistance welded by procedures similar to those used for welding low-carbon steel. Over-heating and use of excessive pressures must be avoided since phosphor bronzes are hot short.

Oxyacetylene Welding

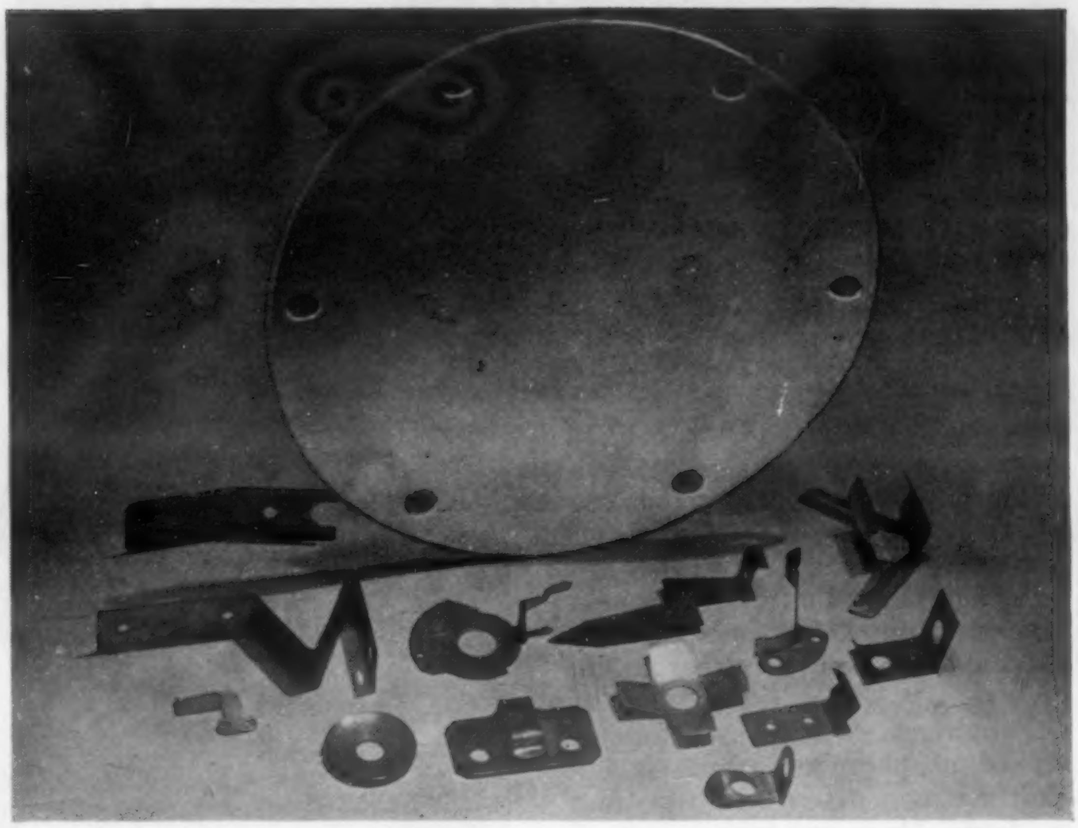
Of the available gas welding processes, the oxyacetylene flame is most frequently employed for joining the phosphor bronzes. Its advantages lie in the high flame temperature and the variety of atmospheres which can be obtained. A strongly oxidizing flame is used in pre-heating and welding, the gaseous mixture being adjusted after melting the base metal to maintain a bright surface on the liquid in the joint. The welding rod contains less phosphorus than is used in rods for carbon-arc welding, and a suitable flux is employed. However, gas welding is not generally used except for repair work because slow cooling rates combined with high shrinkage may result in cracking.

Because of good electrical properties and resistance to arcing, phosphor bronze is widely used for switch parts. (Scovill Manufacturing Co.)



Welding Rods

Welding rods are generally supplied in Grades A, C and D. The rods contain the same quantity of tin as the corresponding wrought alloy but higher phosphorus content. They can be coated or uncoated. Grade A is used for general purpose welding by the carbon-arc and metal-arc methods. Grade C has higher hardness and strength and is suitable for welding bronze, brass and steel. Grade D is used for building up worn machine parts and for high voltage carbon-arc welding of electrolytic copper.



Some of the many parts produced from phosphor bronze sheet and strip. (Scovill Manufacturing Co.)

Surface Finishing

Mechanical and Chemical Cleaning

During fabrication, phosphor bronzes become coated with oils, greases, dirt, metallic particles and similar products. These alloys are cleaned in the same manner as other copper alloys and no unusual problems are involved. The choice of a method depends on the size and quantity of the parts to be handled. Small parts can be cleaned by abrasive tumbling. This operation removes burrs from previous machining operations, frees the parts from oil and dirt, and may work harden the surface. To improve the surface appearance, tumbling can be followed by ball burnishing in a suitable barrel. The highest luster obtainable in a batch operation is achieved in this manner. Larger pieces can be cleaned by sand-blasting, an operation which produces a dull, roughened finish suitable for lacquering.

One of the most generally used methods of cleaning is agitation in a bath containing an alkali. Proprietary mixtures of caustic soda, potash, phosphates, silicates and similar alkalies together with organic emulsifiers and synthetic wetting agents, are used most commonly. The bath is violently agitated to loosen the dirt while the alkali saponifies the animal or vegetable oils and emulsifies the mineral oils, thus removing the soil from the surface of the work. The solutions usually contain from 4 to 8 oz of cleaner per gal of water and the bath is operated at temperatures ranging from 170 to 190 F.

Electrolytic cleaning makes possible the cleaning of many parts for which hand scrubbing is not suitable. Alkali cleaners similar to those used in the mechanical cleaning method are used. However, no emulsifiers or wetting agents are included in the mixture. The work can be made either the cathode or the anode in the cell, although the operation is frequently conducted in two stages. In the first, the work is made the cathode with the objective of obtaining a rapid evolution of gas on the surface to assist in rapid cleaning. For this stage of the process, 4 to 6 oz of cleaner per gal are used with a bath temperature of 160 to 200 F. After rinsing, the work is transferred to a second bath in which it is made the anode for final cleaning. This bath contains from 4 to 12 oz of cleaner per gal and is operated at the same temperature as the cathodic bath. In a system of this kind, the first cleaner removes most of the soil, while the second remains relatively free from grease and dirt. The operating temperature of the bath is determined by the degree of tarnishing which is permissible. Tarnish resulting from alkaline cleaning can be removed by immersion of the part in dilute hydrochloric or sulfric acid followed by rinsing and drying.

Solvent cleaning can be used particularly on screw-machine parts to remove the cutting oil. The material is immersed in a suitable solvent, usually a low-boiling mineral oil fraction. The bath is operated at low temperatures of the order of 120 to 140 F. Solvent cleaners provide only physical cleanliness. If chemical cleanliness is required, as for plating, cleaning with an alkali cleanser must follow.

Vapor cleaning, generally with trichlorethylene as the solvent, is a rapid method of removing oils from the surface of a part. The material to be cleaned is placed in a suitable chamber in which the solvent vapor is condensed. The condensate removes the oil from the surface and leaves the material clean and dry.

Pickling

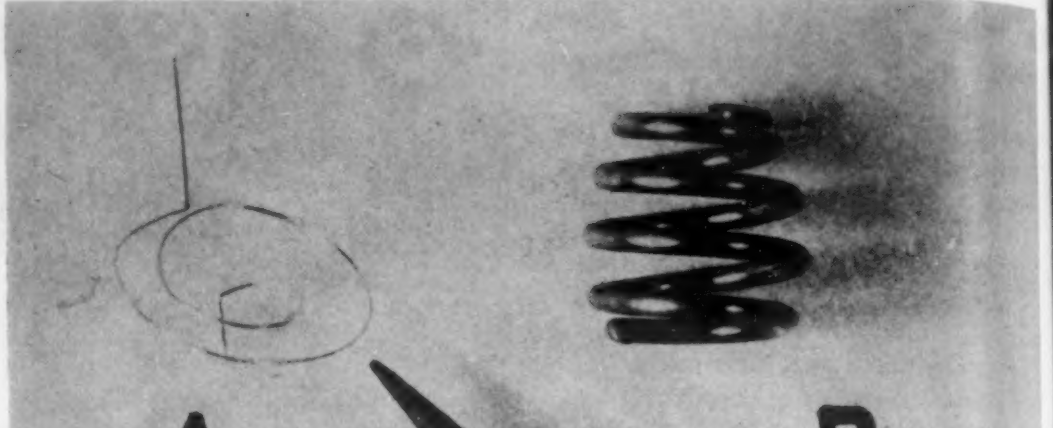
If phosphor bronze is heated in

an oxidizing atmosphere, the surface becomes coated with a film of oxide, the thickness depending on the temperature and time of exposure. To prepare the metal for subsequent operations, such as soldering or welding, or to improve surface appearance, pickling may be required. Oils or grease interfere with proper removal of the oxide film and the part must be cleaned before pickling.

The usual pickling solution is dilute sulfuric acid and the bath is normally operated at 125 to 150 F. If the solution is too strong or too hot, the metal may be pitted. Pitting may result also if the material is immersed in the bath for an extended period of time. Suitable operating conditions can be determined quickly by trial.

The presence of red stains on the surface of phosphor bronze is the most common defect resulting from pickling. There are two sources of this defect. Cuprous oxide is slightly soluble in sulfuric acid and may remain on the surface. If the stains are the result of cuprous oxide deposits, they can be removed with a ferric sulfate or sodium dichromate pickle. Staining may result also if metallic iron or steel are present in the pickling solution. Since iron is anodic to copper, copper can be plated out on the work, causing red stains. Such stains might require a nitric acid dip for removal.

After pickling, the metal must be thoroughly rinsed to remove all traces of the pickling solution before drying. Unless all traces of acid are removed from the work, the surfaces will show acid stains.



Key element in an aircraft landing gear position indicator is the tiny spiral spring (A) made of 0.005-in. dia phosphor bronze wire. The spring serves to return the solenoid-operated indicator card to the neutral position after the actuating coils are demagnetized. Commercial laundry flat-work presses utilize phosphor bronze barrel springs (B) to provide the padded roll surface with a resilient backing. The springs must function satisfactorily under constant flexure in the hot moist atmosphere of the steam chest. (Riverside Metal Co.)

Plating

The excellent corrosion resistance of the phosphor bronzes makes protective coatings on them unnecessary. However, for certain applications, especially for decoration, phosphor bronzes can be plated with gold, silver, nickel or chromium. Providing the parts to be plated are thoroughly clean, no difficulties are experienced in plating with these metals. For the usual application a light deposit is all that is required.

Applications of Phosphor Bronzes

A complete discussion of the applications of phosphor bronzes would require many pages, but a brief description of some of the uses to which these alloys have been applied may assist the materials engineer in deciding where the phosphor bronzes fit into his program.

Some typical applications are:

- Mechanical and electrical springs
- Fourdrinier wire
- Rifle nuts
- Diaphragms and bellows
- Bridge bearing plates
- Gears and pinions
- Bearings and bushings

Because of several outstanding characteristics, the phosphor bronzes are widely used for springs:

1. The elastic properties are excellent. In some tempers, the phosphor bronzes may have elastic limits as high as 90% of the tensile strength. Competing spring materials have failed to replace phosphor bronze in many applications because of lower elastic properties.
2. The excellent resistance to alternating stress, particularly under corrosive conditions, leads to numerous uses.
3. The good electrical properties combined with resistance to sparking make the phosphor bronzes valuable for current carrying springs where arcing may occur. Spring applications are legion. For flat springs, Grade A and Grade C are used in the majority of applications. These include contact springs in communication and power transmission systems, binding posts of the spring-clip type, relay springs, motor control devices, radio and television tube socket contacts, and clock springs, to mention a few applications. In wire form, spring temper Grade A is used most widely while Grades C and D

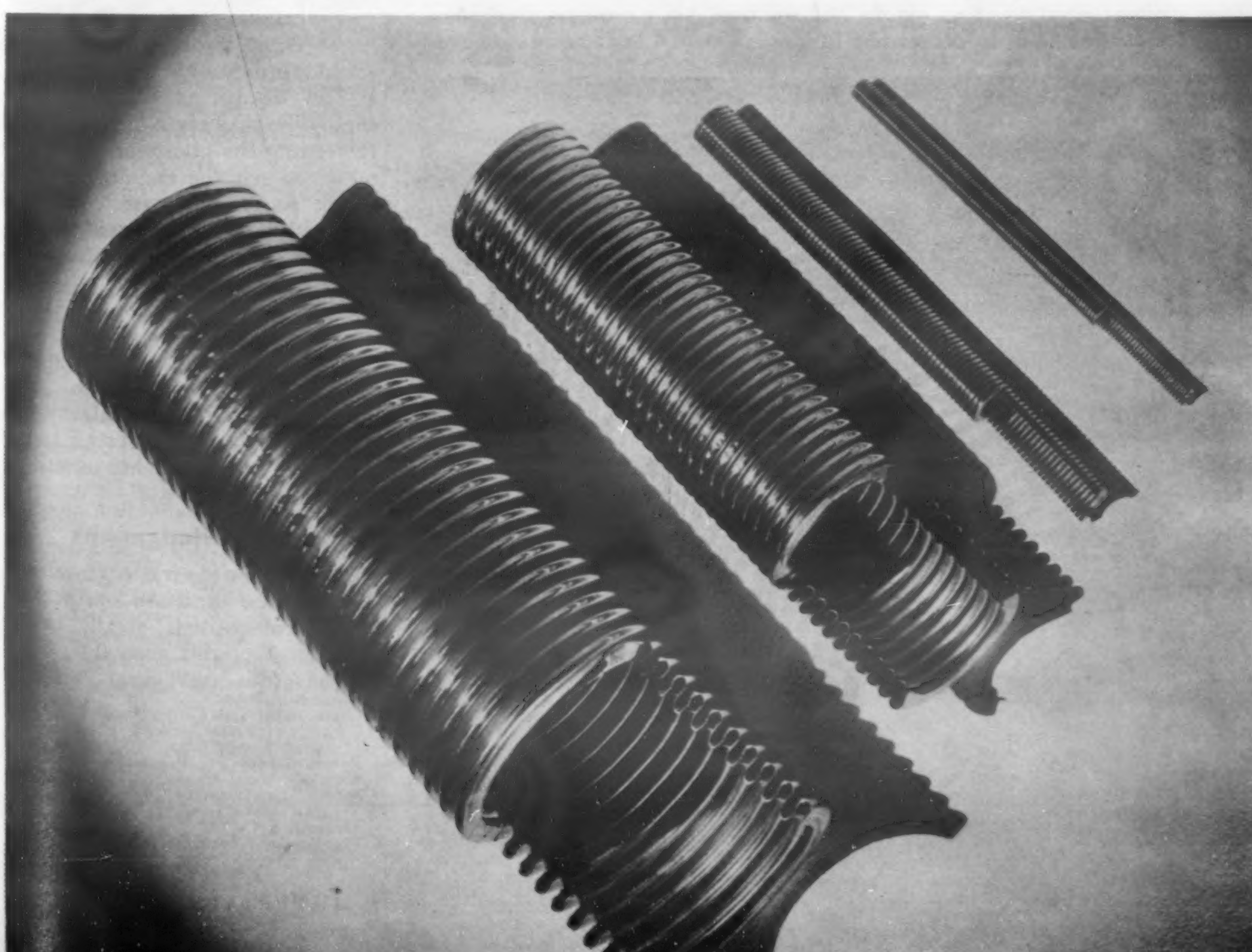
account for less than 5% of the total. Wire is used for the production of tension, torsion and compression springs of many types and sizes. The Bourdon tube used in pressure gages is an example of tubing functioning as a spring. Phosphor bronze Bourdon tubing is used in gages for measuring pressures up to 1000 psi.

About 1/5 of the phosphor bronze wire produced is used in the manufacture of fourdrinier screens. Most types of paper are made by running a suspension of cellulose fiber, together with filler and sizing material, over a traveling endless belt of wire screen on a fourdrinier machine. The mixture is dewatered by suction while it travels on the belt, and a continuous sheet of wet paper leaves the belt at the other end. The requirements of a material to be used in this application are severe. The wire used for fourdrinier screen must have good elasticity to withstand the bending due to running over the rollers at high speed but at the same time must resist stretching, it must resist abrasion from the suction box and corrosion fatigue in contact with

Table 14—Typical Uses of Phosphor Bronzes

Designation	Form	Uses
Phosphor Bronze, 5% (A)	Strip, sheet, plate	Relay springs, electrical contacts, diaphragms, bellows, clutch disks, lock washers, chemical hardware, bearing plates
	Rod	Shafting, welding rod, valve stems, bolts and nuts, pump parts
	Wire	Springs, snap fasteners, cotter pins, wire rope
	Tubing	Bourdon tubing, sleeve bushings
Phosphor Bronze, 8% (C)	Strip, sheet, plate	Extra-strength springs, diaphragms, bellows, lock washers, clutch disks, chemical hardware
	Rod	Welding rod, gears, pinions, chime rods, marine parts
	Wire	High-strength springs, fourdrinier wire, welding wire, cotter pins
	Tubing	Bourdon tubing, sleeve bushings
Phosphor Bronze, 10% (D)	Strip, sheet, plate	Extra-strength and resilience springs, heater bars, bearing plates, bridge and expansion plates
	Rod	Rifle nuts for rock drilling equipment, gears, pinions, bushings, welding rod
	Wire	High-strength springs, welding wire, electrical contacts
Phosphor Bronze, 1.25% (E)	Strip, sheet, plate	High-conductivity light-duty springs, electrical contacts, pole-line hardware, flexible hose
	Rod	Hot forgings
	Wire	Signal wire
Leaded Phosphor Bronze, 5% (B1)	Strip	Formed parts with punched holes
	Rod	Screw machine products, pinions, small gears, bearings
Special Free-Cutting Phosphor Bronze 444 (B2)	Strip	Gears, pinions, washers
	Rod	Bearings, bushings, screw-machine products, shafts

Because of flexibility, long life and resistance to vibration, Grade E phosphor bronze is widely used for metal hose. Sizes shown range from 7/16-in. O.D. by 1/4-in. I.D. to 5-in. O.D. by 3 3/4-in. I.D. (Revere Copper & Brass, Inc.)



sulfite liquors and other paper-making chemicals, and it must be fine enough to permit the weaving of a screen with the maximum percentage of open spaces to facilitate draining of the wet pulp. Annealed Grade C and Grade F (6½% tin) phosphor bronze wire, 0.010 in. in dia have been outstanding in this application. Other uses for phosphor bronze wire include snap fasteners, cotter pins, wire rope, electrical contacts and welding wire.

With the exception of the leaded alloys, the largest use of phosphor bronze rod is in the production of rifle nuts for compressed air drilling equipment. These nuts, which are produced in sizes up to 3½ in. in dia, must stand up under very severe conditions. Since a stoper, for example, may operate at speeds up to 2000 strokes per minute, the rifle nut which serves to impart a twisting motion to the drill and is a key part in the operating mechanism must have high resistance to impact, good abrasion resistance toward such materials as sand, silica dust and various metal dusts, corrosion resistance toward salt water and various acid mine waters, and good fatigue properties. Of all materials tried for this application, Grade D phosphor bronze has been found most satisfactory. Other uses for rod are bolts, nuts, pump parts, gears and pinions, and hardware. Grade E, the only alloy of the group which has satisfactory hot working qualities, is used frequently in rod form in the production of hot forgings.

The excellent fatigue properties of phosphor bronzes are the basis for their wide use as diaphragms and bellows. The "voice" of the steamship foghorn is controlled by a diaphragm constructed of thin metal disks riveted together at the center. This diaphragm vibrates at the rate of 200 to 400 times per sec to control the blast of air which causes the horn to "speak". The diaphragm must stand up in a salt-ladened atmosphere under rapidly alternating stresses and be ready to function instantaneously. Phosphor bronze has been widely used for these diaphragms. Such diaphragms made from very thin corrugated disks are used also in altimeters and air speed indicators. Applications of bellows range from those used in large oil-filled transformers to control the expansion of the oil to the "Iron Lung", in which a phosphor bronze bellows simulates actual breathing.

Phosphor bronze bearing plates are installed between bridge spans to permit free movement during the expansion and contraction of the bridge. These alloys are selected for the purpose because they resist seizing and deformation under the high loads involved. Among other uses of flat products are roll-inserts in machines producing corrugated paper, perforated plates for sieves to be used under corrosive conditions, clutch plates for aircraft engines, lock washers, and chemical hardware.

Annealed Grade E phosphor bronze is used widely for flexible metal hose because of good flexibility, resistance to vibration, and resistance to expansion and contraction caused by sudden temperature changes. This grade is also used for pole-line hardware such as cable clamps, U-bolts and nuts.

Since the phosphor bronzes have low coefficients of friction with most other metals, they find considerable application in bearings and bushings. Although Grades A and C find some uses in this field, the leaded alloys are employed most frequently. Other uses of the leaded alloys include screw machine products for applications under severely corrosive conditions.

These are some of the more common applications of phosphor bronzes. Their good fatigue properties, excellent corrosion resistance, high strength and ductility will suggest other uses to the materials engineer seeking the right material for a severe application.

This manual is not intended to supply the answers to the problems of fabricating the phosphor bronzes but rather to give the engineer a picture of the properties, characteristics and potentialities of these materials. A material can prove satisfactory for a given application only if it is engineered properly. This means, in the case of the phosphor bronzes, selection of the right grade and the right temper for the application. Such selection can be made only by consulting the producer of the bronze and being guided by his recommendations.

Bellows, made of Grade A phosphor bronze, used to pump air in the "Iron Lung". This bellows simulates actual breathing, and the "full size lung" has a maximum air displacement of 72 cu in. per movement. (Revere Copper & Brass, Inc.)

Acknowledgments

The following organizations, through their literature and personal help, have assisted greatly in the preparation of this manual.

American Brass Co.
Bridgeport Brass Co.
Chase Brass and Copper Co.
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Revere Copper and Brass, Inc.
Riverside Metal Co.
Scovill Manufacturing Co.
Seymour Manufacturing Co.
Sherman & Co.
Tin Research Institute, Inc.

Materials & Methods

Materials Engineering File Facts

NUMBER 214
September, 1951

MATERIALS:
Stainless Steel

High Temperature Properties of Stainless Steel Tubing

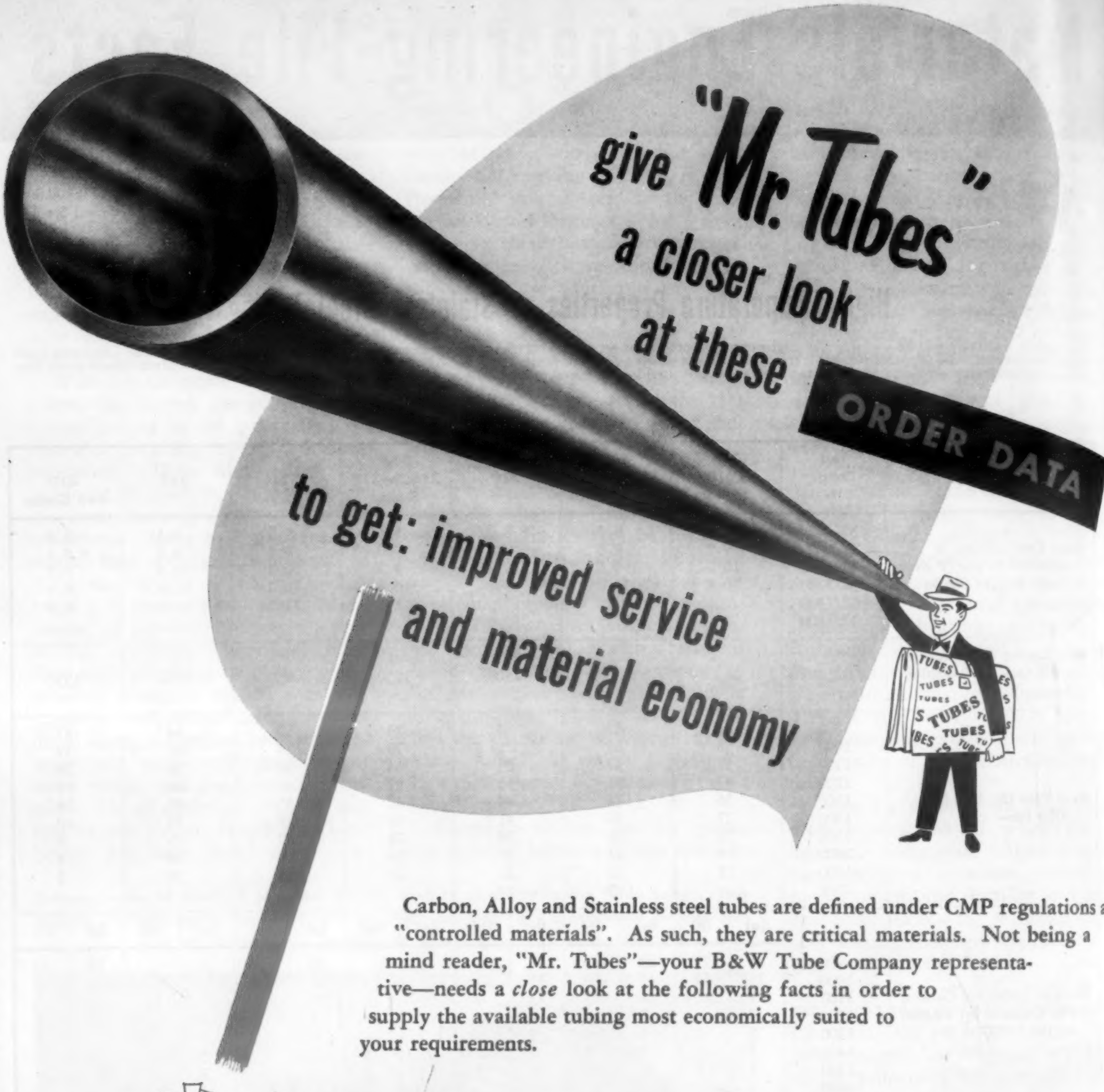
The data in this table will be useful to the engineer whose process or product involves operation at elevated temperatures. According to The Carpenter Steel Co.'s metallurgists, who prepared this table from a number of sources, average values are generally given. Although specific results at a given temperature may vary in full-scale commercial application, the table should be useful as a general guide to the proper selection of material.

	Test Temp., F	304 C#10 Similar	309 309Cb–330 C#20 Similar	310	316 316Cb–317 Similar	321	347	430 443 Similar
Mean Coef. of Exp. in Millionths In. per °F over Temp. Ranges Shown	32/212	9.6	8.3	8.0	8.9	9.3	9.3	5.8
	32/600	9.9	9.3	9.0	9.0	9.5	9.5	6.1
	32/1000	10.2	9.6	9.4	9.7	10.3	10.3	6.3
	32/1200	10.4	10.0	9.7	10.3	10.7	10.6	6.6
	32/1500	....	....	....	11.1	11.2	11.1	6.9
	32/1800	....	11.5	10.6	....	....	....	....
Safe Scaling Temp. for Cont. Serv. in Oxidizing Atmos., F	....	1650	2000	2100	1650	1650	1650	1550
Short Time Ult. Ten. Str., 1000 Psi	900	61	67	74	74	56	64	47.5
	1000	58	63	71	70	54	61	39
	1100	51	57	65	64	50	56	29
	1200	43	52	54	57	43	49	21
	1300	36	44	49	47	35	42	14
	1400	27	35	41	36	28	33	10
	1500	21	28	34	28	22	25	6
	1600	16	23	27	24	18	20	4
	1700	12	16	21	21	15	16	3
	1800	....	13	17	....	....	....	....

	Test Temp., F	304 (a)	304 (b)	309 (a)	309 (b)	310 (a)	310 (b)	316 (a)	316 (b)	321 (a)	321 (b)	347 (a)	347 (b)	430 (a)	430 (b)
Stress (in 1000 Psi) Causing 1% Creep in (a) 10,000 Hr; (b) 100,000 Hr	900	25	17	23	15	..	..	..	..	25	..	..	..	16	12
	1000	18	11	17	10	17	11	25	15	18	..	25	..	8	7
	1100	12	7	11	7	13	9	20	10	13	..	17	14	4	3
	1200	7	4	7	5	8	6	14	7	8	..	11	6	2	2
	1300	5	2	5	2	5	4	9	4	5	..	6	3	1	1
	1400	3	1.5	2	1	2	2	5	3	3	..	3	2	1	..
	1500	2	1	1	1	1	1	3	2	1	..	2	1	..	..
	1600	..	..	..	..	..	..	..	..	..	..	1	..	..	..

	Test Temp., F	304	309	310	316	321	347	430
Stress (in 1000 Psi) Causing Rupture in 1000 Hr	1000	....	....	32	....	....	....	....
	1100	22	....	22	33	26	31	....
	1200	14	20	14	25	17	18	....
	1300	9	12	8	17	10	11	....
	1400	6	8	5	11	6	8	....
	1500	4	5	3	7	4	5	....
	1600	....	3	2	4	....	....	....
	1700	....	2	1.5	3	....	....	....
	1800	....	1	1	1	....	....	....
Embrittling Grain Growth: Yes or No / Temp. Range, F	....	No / Under 1800	No / Under 1800	No / Under 1800	No / Under 1800	No / Under 1800	No / Under 1800	No / Under 1800
Melting Point, F	....	2550/2650	2550/2650	2550/2650	2500/2550	2550/2600	2550/2600	2600/2750
Res. to Intergranular Carbide Prec.: Short Time Exp. to Temp.	....	Poor	Good	Good	Poor	Good	Good	Excellent
Exp. to Cont. Serv. in Sens. Temp. Range	....	Poor	Poor	Fair	Poor	Good	Good	Excellent
Ther. Cond., Btu/Sq Ft/Hr/°F/In.	212	9.4	8.0	8.0	9.4	9.3	9.3	15.1
	932	12.4	10.8	10.8	12.4	12.8	12.8	15.2
Specific Heat, Btu/Lb/°F	32/212	0.12	0.12	0.12	0.12	0.12	0.12	0.11

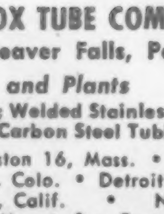
Courtesy The Carpenter Steel Co., Alloy Tube Div.



Carbon, Alloy and Stainless steel tubes are defined under CMP regulations as "controlled materials". As such, they are critical materials. Not being a mind reader, "Mr. Tubes"—your B&W Tube Company representative—needs a *close* look at the following facts in order to supply the available tubing most economically suited to your requirements.

1 All related CMP authorizations and government contract numbers.

2 Any acceptable alternates in type, finish, composition, and size.



3 A brief, informative description of your intended fabricating methods.

4 A description of the end-use, exact as to product and its service.

THE BABCOCK & WILCOX TUBE COMPANY

Executive Offices: Beaver Falls, Pa.

General Offices and Plants

Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

Sales Offices: Beaver Falls, Pa. • Boston 16, Mass. • Chicago 3, Ill. Cleveland 14, Ohio • Denver 1, Colo. • Detroit 26, Mich. Houston 2, Texas • Los Angeles 15, Calif. • New York 16, N. Y. Philadelphia 2, Pa. • St. Louis 1, Mo. • San Francisco 3, Calif. Syracuse 2, N. Y. • Toronto, Ontario • Tulsa 3, Okla.

B&W SEAMLESS and WELDED TUBES

TA-1640-G

Materials & Methods

Materials Engineering File Facts

NUMBER 215
September, 1951

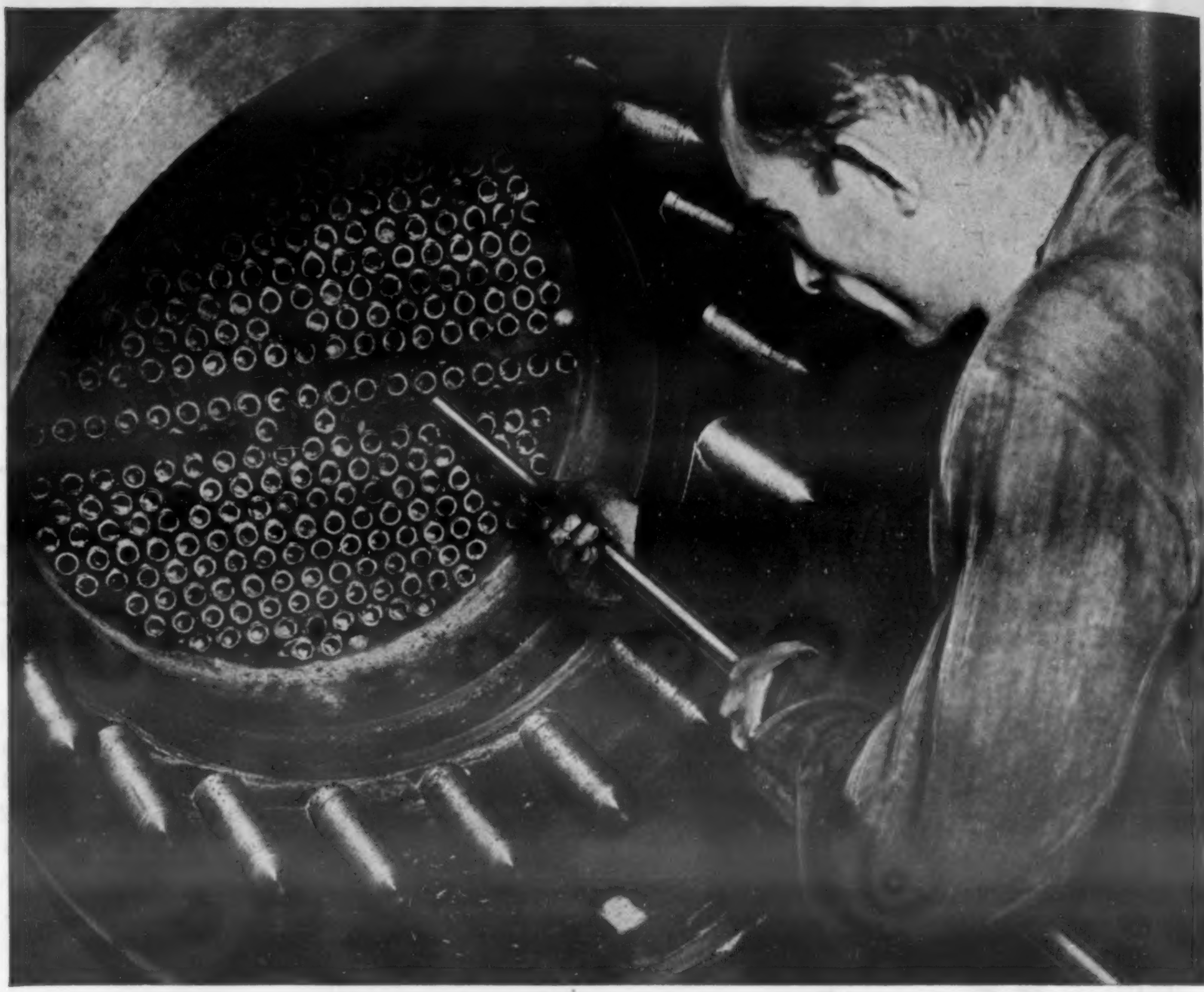
MATERIALS:
Rubber

Swelling and Tensile Characteristics of Crude Sponge Rubber Immersed in Common Oils and Solvents

Oil or Solvent	Increase in Volume after 30-Day Immersion at Room Temp., %	Loss in Tensile Strength after 30-Day Immersion, %
Water	0–25	0–10
Steam (after 8 Hr)	25–75	.....
Ethyl Alcohol	0–25	0–10
Methyl Alcohol	0–25	0–10
Amyl Alcohol	0–25	0–10
Isopropyl Alcohol	0–25	10–25
Acetone	0–25	0–10
Methyl Ethyl Ketone	25–75	25–35*
†Benzol	75 or greater	.....
†Toluene	75 or greater	.....
†Xylene	75 or greater	.....
†Naphtha	75 or greater	.....
Glycerin	0–25	0–10
†Chloroform	75 or greater	.....
†Carbon Tetrachloride	75 or greater	.....
Clorox	0–25	10–25
†Butyl Acetate	75 or greater	.....
Ethyl Acetate	25–75	25–35*
Ethylene Glycol	0–25	0–10
Diethylene Glycol	0–25	0–10
†Chlordane	75 or greater	.....
Dibutyl Phthalate	0–25	25–35*
†Carbon Bisulfide	75 or greater	.....
†Ethylene Dichloride	75 or greater	.....
†Turpentine	75 or greater	.....
†Paraffin Oil	75 or greater	.....
Cotton Seed Oil	25–75	10–25
†Linseed Oil	25–75	.....
†Motor Oil SAE 30	75 or greater	.....
†ASTM Oil No. 1	25–75	.....
†ASTM Oil No. 3	75 or greater	.....
Acetic Acid 5%	75 or greater	.....
†Acitic Acid Conc.	75 or greater	.....
Hydrochloric Acid Dilute	0–25	10–25
†Hydrochloric Acid Conc.	75 or greater	.....
Sulfuric Acid Dilute	0–25	0–10
†Sulfuric Acid Conc.	75 or greater	.....
†Nitric Acid Dilute	0–25	.....
†Nitric Acid Conc.	75 or greater	.....
Sodium Hydroxide 3N	0–25	.....
Sodium Hydroxide Dilute	.....	0–10
Ammonium Hydroxide Dilute	25–75	10–25
Ammonium Hydroxide Conc.	25–75	10–25

* *Immersed for one week.*
† *Crude sponge rubber not recommended for use in contact with these substances.*

This table adapted from data published by the Sponge Rubber Products Co.



One of the "Four Hundred"

EVERYTHING's going up. Everything, that is, except the cost of *power*. Fuel is up. Labor is up. Equipment cost is up. But not the cost per delivered kilowatt-hour.

Power plant engineers let you in on the secret: "It's a principle," they say, "*the higher you raise steam temperature and pressure, the more power you get per pound of fuel.*"

But there's an added factor in this seemingly simple formula. For already, boiler pressure-temperatures have been pushed up until the steam lines glow red; and that calls for supplying feedwater under conditions that are something special. Look, for example, at the heater pictured here.

It contains more than 400 metal tubes, totalling 5 miles in length. Every minute, the heater rams 1000 gallons of 450°F. water into the thirsty maw of the main boiler at a pressure of 3,200 pounds per square inch.

So there, Mr. Designer, is your problem. To find a material to make those thin-wall tubes with the strength to stand such temperatures and pressures . . . plus a few extras for good measure:

Tubes must be elastic, to shrink and swell in tune to the steel tube sheets; possessed of high heat transfer properties, an extremely low corrosion rate, erosion-resistant, and easy to weld.

The designers who faced those eight "musts" found their answer in one metal: Monel, one of the family of INCO Nickel Alloys.

What of the Metal Problem facing You?

Could one or another of the Inco Nickel Alloys help you solve it? Very possibly. Write us about it. Under present conditions, so much Nickel is needed for defense work that we have to stretch our production to cover the most essential needs for INCO NICKEL ALLOYS. But we are ready right now to help you with ideas and suggestions for your present production and future planning.

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.

Nickel INCO Alloys

NUMBER A6
SEPTEMBER 1951

EUTECTIC LOW TEMPERATURE WELDING ALLOYS®

MATERIALS: WELDING AND BRAZING FILLER METALS

"Eutectic Low Temperature Welding Alloys" are proprietary alloys. Their inherent feature is that of maximum surface alloying with the parent metal below its melting point. These alloys thus insure better weldability and joints of higher physical properties than those obtained with conventional welding, brazing, and soldering materials. Free Consultation-Demonstration anywhere, anytime. For larger complete chart, contact your local District Engineer.

MAIN USES — Rods marked with an * are the most versatile and most popular. Others are special rods designed for specific purposes.

FOR CUTTING, CHAMFERING, PIERCING, GOUGING, JOINT PREPARATION OF ALL METALS

CutTrode 1 (Universal)—Ideal for cutting, chamfering, gouging, piercing steel, copper, aluminum; nickel, preparing cast iron for welding.
CutTrode G (Gouging) — Developed primarily for gouging and chamfering.

FOR CAST IRON

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR TORCH		
14FC*	All purpose, high strength, easily machinable	1400	25-30
141	All purpose (same as 14 without coating)	1400	25-30
142FC	"Anti-Porosity" coated; easy to use; machinable	1650	55
140	Nickel cast iron; high strength cast iron	1400	35 40
146FC	Bronze-type rod for ferrous and non-ferrous metals	1490-1625	54
15	Sealing and filling of cracks, defects, etc.	450	5
185FC*	Bronze welding and for overlay	1400	60
148FC	For Bronze welding; extra-high wetting action	1400	55
	FOR ARC		
24*	High strength "cold" welding; machinable	AC-DC	50-55
25	High strength; machinable; for alloy cast iron	AC-DC	60
24B	Where cast iron filler is desired (preheat)	AC-DC	35
26	All purpose—high strength	AC-DC	60

FOR ALL STEELS

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR TORCH		
16FC	All purpose, high strength, low melting	1400-1600	100S
1600	Special Silver Alloys: Medium low melting	1425M	100S
1601	Special Silver Alloys: High strength; for tungsten carbide	1220M	100S
1800	Special Silver Alloys: Ferrous and non-ferrous	1150M	100S
1801	Special Silver Alloys: Lowest melting; high speed steel	1120	—
1807	Special Silver Alloys: For extra-high remelt temperature; silver alloy	1760M	30-32S
70	For repair and maintenance; contains chrome-nickel	AC-DC	82
71	For production of chrome-moly steel assemblies	AC-DC	100

For low melting solders, refer to EutecRod 150, 151, 151B, 153, 155 listed under "Copper, Brass, Bronze". They can be applied to steels with equal success.

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR ARC		
60	All purpose, thin sheet, mild steel	AC	65-72
600	All purpose, thin sheet, mild steel	DC	65-72
66*	High strength, low alloy steel, cast iron	AC	80
660*	High strength, low alloy steel, cast iron	DC	70-75
67*	All purpose, high strength, alloy steel	AC	90
670*	All purpose, high strength, alloy steel	DC	90
68	For carbon, spring, tool & die, and higher alloy steels	AC	95-100
680	For carbon, spring, tool & die, and higher alloy steels	DC	95-100
6000	For uphand welding of mild steel; poor fits	AC-DC	72
Hand-Omatic	For "contact" welding; less fatigue, higher speed	AC-DC	72
Steel-Tectic	Low amperage, "non-stop" electrode; high strength	AC-DC	70-80

FOR STAINLESS STEELS

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR TORCH		
StainRod A (FC)	For gas welding stainless; high strength	—	80
	FOR ARC		
StainTrode A	Type #301, 302, 304, 321 and 347	AC or DC	85
A Mo	Moly, all purpose type #303, 315, 316, 317 and 329	AC or DC	82
B	All purpose type #301, 302, 304, 305, 306 and 308	AC or DC	85
B Mo	Moly, for types # 303, 308, 315, 316, 317 and 329	AC or DC	83
C	All purpose type #309	AC or DC	91
D	All purpose type #310	AC or DC	92-95

FOR COPPER, BRASS, BRONZE

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR TORCH		
18FC*	Universal uses, high strength	1400 1600	55
180	Substitute for silver solders	1290	—
181	Special Silver Alloys: Medium low melting, for defects	1300	—
1800	Special Silver Alloys: Ferrous and non-ferrous	1150M	100S
1801	Special Silver Alloys: Lowest melting	1120	—
1803	Special Silver Alloys: High strength joints on thin or intricate sections	1185	140
1807	Special Silver Alloys: Silver alloy; extra-high remelt temperature	1760M	26S
1805	Silver bearing brazing-type alloy; high strength	1400-1600	65
183FC	Weld thin and medium copper sections	1950	34-38
184FC	Weld heavy copper sections	1960	34-38

FOR COPPER, BRASS, BRONZE (cont.)

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR TORCH (Cont.)		
150	High melting solder, filler for defects	600M	—
151	Lowest melting solder applications	350-400M	—
151B	Lead-free solder type alloy for steel, copper, nickel	425-450 M	—
153	Tin free solder applications	575M	—
155	For ferrous and non-ferrous; stronger than solder	725M	—
182	Low melting; ideal for thin sheet or tubing; good color match	1800	45
800	Low cost substitute for silver solder	1310	—
	FOR ARC		
28*	All purpose brass and bronze	AC	45
280*	All purpose brass and bronze	DC	45
29	All purpose silicon and high copper bronze	AC	45
290	All purpose silicon and high copper bronze	DC	45
30	All purpose for copper	AC	32
300	All purpose for copper	DC	32

FOR NICKEL AND NICKEL ALLOYS

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR TORCH		
20FC*	All purpose, high strength — free flowing	1400	60
200	Special low melting silver alloy	1220	—

For low melting solders, see 151, 153 (copper listing).

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR ARC		
2000	For Monel; high strength; corrosion resistant	AC-DC	65
2001	For Nickel; for corrosion-resistant welds	AC-DC	50-55

FOR ALUMINUM AND ALUMINUM ALLOYS

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR TORCH		
190	T-joints, fillets, lap joints; thin sheet	1000	22-24
199B	Extremely low melting, joining and filling	350M	—
210FC	Cast and sheet aluminum; high strength	1075	20
19	Low melting; filling defects	675	—
21FC	Best for butt joints, sheet, tubes, shapes	1075	20
22FC	Non-silicon rod; perfectly color-matched welds on 28, 38	1175	14
	FOR ARC		
2100	All purpose, sheet and casting	DC	20
2101	Highest strength electrode; easy-to-control; fume-free	DC	34 (on ST)
2102	Silicon-free; highest corrosion resistance; anodizable	DC	15

FOR MAGNESIUM ALLOYS

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR TORCH		
1900*	High strength for sheet, tubes, shapes	1110	29
1902	Ideal for thick-to-thin welds; flows like silver solder	1100	25

FOR ZINC DIE CASTINGS

Rod No.[1]	Main Uses	Bonding Temp.[2], °F. (approx.)	Tensile Strength[3] (x1000), psi (approx.)
	FOR TORCH		
196	Ideal for repairs of carburetors, grilles, etc.	675	17-24

FOR HARD OVERLAYING—EUTECHROM GROUP FOR MAXIMUM HARDNESS

Rod No.[1]	Main Uses	General Application	Hardness, Rockwell[3]
	FOR TORCH		
1FC	All purpose—unmachinable	AGAINST ABRASION	C58-60
11FC	High abrasion, oil drill tools, etc.	AGAINST ABRASION	Carbides
13FC	Cast iron, cast steel, etc.	AGAINST ABRASION	C50-55
188FC*	Ferrous and non-ferrous	AGAINST ABRASION	C55-62
2B FC	All purpose—machinable	AGAINST IMPACT	C30-32
3FC	Manganese steel	AGAINST IMPACT	C26-30
5 OH FC	For oil hardening steels; heat treatable	AGAINST IMPACT	C56-61
5 HSS FC	Cutting edges—heat treatable	HIGH SPEED STEEL	C58-62
5 HW FC	Heat treatable alloy for hot working tools and dies	HOT WORK TOOLS	C45-52
5 AH	Hard "as deposited"; against severe abrasion	AIR HARD'G TOOLS	C58-60
5 WH	Can be quenched to high hardness in water or "Eutec-Brino"	WATER H'RD'G TOOLS	C60-63
7 FC	All purpose, against corrosion	CORRO-SION	C48-54
	FOR ARC		
2	All purpose—unmachinable	AGAINST ABRASION	C50-55
2X	For all-around use; good corrosion resistance	AGAINST ABRASION	C55-60
10	For severest wear; high hardness at high temperatures	AGAINST ABRASION	C63-68
12	High abrasion, oil drill tools, etc.	AGAINST ABRASION	Carbides
130	Cast iron, cast steel, etc.	AGAINST ABRASION	C50-55
1880*	Ferrous and non-ferrous	AGAINST ABRASION	C55-62
2B	All purpose—machinable	AGAINST IMPACT	C20-22
4	Manganese steel; work hardens	AGAINST IMPACT	B90
6 OH	For oil hardening steels; heat treatable	AGAINST IMPACT	C56-61
6 HSS	Cutting edges—heat treatable	HIGH SPEED STEEL	C58-62
6 HW	Heat treatable alloy for hot working tools and dies	HOT WORK TOOLS	C45-52
6 AH	Hard "as deposited"; against severe abrasion	AIR HARD'G TOOLS	C58-60
6 WH	Can be quenched to high hardness in water or "Eutec-Brino"	WATER HARD'G TOOLS	C60-63
8	All purpose, against corrosion	CORRO-SION	C48-54

For tough, machinable, heat-resistant overlays, see 67, 68 (all-steel listing). — BRI-NELL

BRONZOCHROM GROUP (TORCH ONLY)

Rod No.[1]	Main Uses	General Application	Hardness, Brinell
185FC	High strength; all purpose steels	FOR TOUGH MACHINABLE OVERLAY	130-140
186	All purpose — harder than 185FC	FOR TOUGH MACHINABLE OVERLAY	150
187	Very hard, copper alloys	FOR TOUGH MACHINABLE OVERLAY	175-185

EUTECRODS-"500 SERIES"-For Inert Gas-Shielded Arc Welding

501—For aluminum, l.m.
502—For aluminum sheet, m.l.
503—For pure aluminum, c.r.
509—For all bronzes, m.l.
510—For silicon bronze, c.r.
511—For copper, c.r.
512—For copper alloys, m.l.
513—For light copper, l.m.
520—For monel, c.r.
521—For nickel alloys, c.r.
530—For magnesium, m.l.
531—For magnesium sheet, l.m.
565—For stainless steel, c.r.
571—Hard overlay cast iron
572—Hard facing steel
573—Machinable overlays, c.r.
574—Overlay, manganese steel, c.r.
575—Overlays, tool steels, c.r.
576—Abrasion resistance, l.m.
580 For cast iron repairs, c.r.

CODE: l.m. = low-melting m.l. = medium-low melting. c.r. = corrosion resistant, same as parent metal.

CHEMICAL WELDING AND BRAZING AIDS—

"Form-A-Jig" — Holds small sections, avoids jig-making.

"Instant Hardner #1"— Hardens any steel with ordinary torch.

Pre-Cleaners for Aluminum, Magnesium — Insure porosity-free, sound bonds.

"Eutecto-Mask" — Protects parts against heat, spatter, etc.

"Instant Hardner #2"— Same as #1 but with hard particles.

Post-Cleaner for Aluminum — Removes welding residue.

"Anti-Capillary Compound"— Saves welding alloy; insures neater joints.

"Eutec-Brino" — Brine-type solution for heat-treating, quenching.

"Eutec-Mark-A-Cut" Pencil—Draws guide lines on hot or cold metal.

Specially Compounded Fluxes for all metals.

1. FC means ready-flux-coated. Also available bare.
2. The base metal temperature required in the weld area to obtain a bond. Applies to beveled joints and overlays. "M" after the value shown signifies "melting point of alloy."
3. All values are "as deposited" and can at times be increased by heat-treatment. Tensile strength also depends on joint design and condition of base metal. "S" after the value shown signifies shear strength, psi.

* Most popular rods for everyday use.

Sponsored and prepared for publication in Materials & Methods by

EUTECTIC WELDING ALLOYS CORPORATION
172nd STREET AND NORTHERN BLVD., FLUSHING-NEW YORK, N.Y.


Tail Light—Stop Light Lens
FORD
Front and Rear Crest
Again . . . FORD Uses
PLEXIGLAS
for Molded Automotive Parts
"Built for the years ahead," '51 Fords are extra husky and handsome. Their visible plastic parts must have *lasting* beauty and strength—and PLEXIGLAS V acrylic plastic molding powder meets the requirements. Inside and outside cars, and inside and outside the automotive industry, PLEXIGLAS V molded parts have beauty, dimensional stability, and outstanding resistance to heat, age, and weather. Write for our booklet showing typical parts molded from PLEXIGLAS acrylic plastic molding powders.
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Steering Wheel Ornament

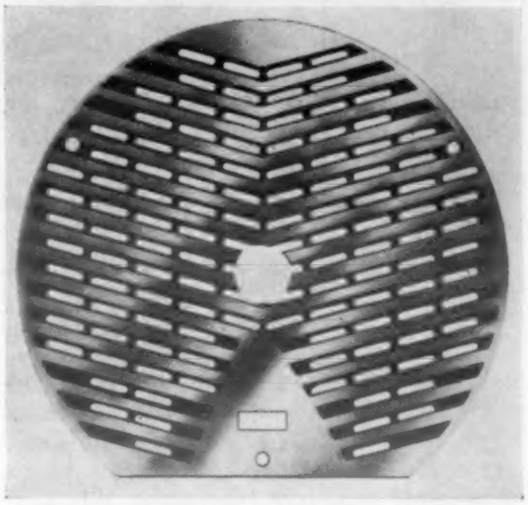
New Materials and Equipment

Plastic Replaces Metal Used for Decorative Purposes

Metallic acetate, a product of *Coating Products, Inc.,* New York City, is said to be an effective substitute for metals used for decorative purposes. A plastic material which looks like metal and possesses a mirror-like finish, the acetate offers considerable cost reduction.

Applications have been found for the material in radio set manufacture where a gold metallic acetate has been substituted for metal on the grill. The acetate is laminated to board to look like the original metal it replaces. Since the original part had no functional role other than decorative, the effect is the same with the exception that a critical material need not be used. Another example is the juke box. The company reports that one of the largest manufacturers of juke boxes is now utilizing metallic acetates as an ideal substitute. The interior of the cabinet was formerly lined with a high finish metal. Today, the same results are achieved with an embossed silver metallic acetate. All around the record mechanism, a solid mirror-like interior reflects the same visual impression without the use of essential materials.

Still another usage of the new material is in the name plate and metal sign fields. Since the plastic can be laminated to heavy board, a quality of rigidity is obtained and another helpful substitution is accomplished.



This grill used in radio set manufacture uses metallic acetate to replace critical metal.

Improved Bronze Bearings Announced

These bronze bearings range from a minute size up to sizes as large as 24 in. in dia.

An enlarged and improved line of bronze bearings and bushings has been announced by *Bronze Bearings, Inc.,* Cranford, N. J., which range from small sizes no bigger than the end of one's finger up to sizes as large as 24 in. in dia.

Finishes ranging from an accurate machine finish for precision application to a semi-finish for rough work are now available, and the parts can be economically produced in any quantity from a single bearing to as many as a thousand or more.

An outstanding feature of these bearings is that they are cast in the company's own foundry from rigidly controlled bearing metals (of the proper type for the particular use) that have under rigid tests proved their quality. They also are said to incorporate special lubrication designs that would meet individual requirements.

Flanged types of bearing and bushings are provided not only in all finishes, but also with special flanges, to order.

Heating Unit Designed for Treating Torsion Bars

Currently being used in various large defense plants for heat treating 77-in. torsion bars for light, medium and heavy army tanks, the new heater offered by *Frank C. Cheston Co.,* 30 Church St., New York 7, is said to eliminate diameter loss due to scaling and decarburization and to give constant Rockwell readings throughout the length of the bar, permitting heat treating operations on a machine shop floor without heat blast, fumes or grime.

Used for bringing 1- to 2½-in. dia bars to 1600 F, in heating periods ranging from 1 min, 30 sec to 4 min, the unit can also be used for annealing bars between draws, heating for straightening bars, heating for making bolts, rivets, etc.

Equipped to handle bars of any diameter from ⅜ to 2½ in., any length from 4½ to 30 ft, in temperature ranges from 200 to 2200 F, the unit is said to offer a heating cost approximately 70% below any other method.

This torsion bar heater will handle bars of any diameter from ⅜ to 2½ in., any length from 4½ to 30 ft., in temperature ranges from 200 to 2200 F.

New Materials and Equipment continued

These bronze steel-backed bearings are available in a range of sizes to fit specific applications.

Bronze Steel-Backed Bearings Made by New Process

Bronze steel-backed bearings combining both strength and lightness are now available for heavy-duty applications, especially those involving temperature extremes, from *Beauideal, Inc.,* 867 S. Water St., Saginaw, Mich.

Produced by a new, nonmechanical bonding process, the bronze of the bearing adheres absolutely to the steel backing, and tests have proved that the bond between the bronze and the steel is impossible to break. Steel-backed bearings were cut and straightened. After straightening, one end was held in a vise while the opposite end was twisted until the piece broke. The result (as shown in the photo) was that the bronze checked, but at no point was there indication of a separation between the bronze and the steel.

Bearings, using a steel such as Nitralloy combined with a high leaded bronze, can be heat treated to a temperature of 1100 to 1200 F. Using a long grain bronze, processing can be accomplished to 1500 to 1600 F.

Used extensively at the present time in military production of planes and tanks, the bearing's light bronze wearing surface is claimed to lessen the possibility of extrusion under heavy loads.

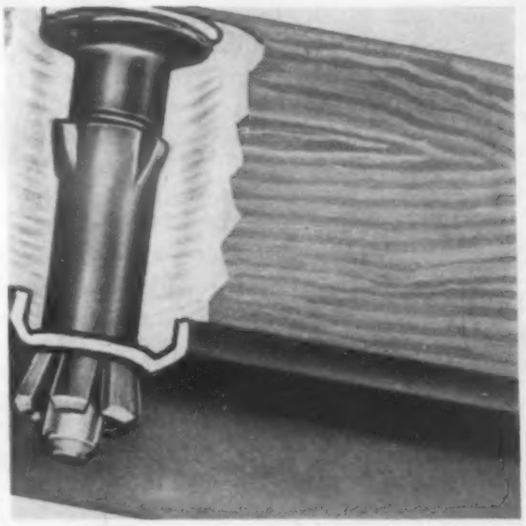
Self-Locking Fastener Reduces Labor Costs

A new one-man expansion sleeve type fastener has been announced by *Square Tool & Die Co.,* Chicago Drillet Div., 1550 N. Fremont St., Chicago 22.

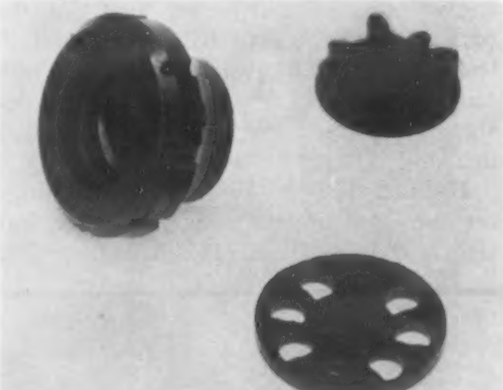
Created to reduce labor costs, this fastener is said to be radically different in design from any other. Primarily it eliminates the second man required in inserting and tightening up conventional bolt and nut, as it has no nut.

The bolt is simply inserted in the hole and a pneumatic tool drives it through the sleeve and expands six prongs at the sleeve's bottom. This forms an extremely tight grip which cannot work loose due to vibration. The bolt head automatically countersinks itself below the wood surface, thereby eliminating the possibility of ripping and tearing of materials caused when passing over exposed bolt heads.

This fastener is made in sizes from ¼ to 1 in. in dia, lengths from 1 in. up, and with hex, square, round, flat or slotted heads.



New Materials Offer Variety of Applications



These parts represent typical applications of the new phenolic impact molding material.

A new, hard, fibrous material developed especially for electrical insulation applications requiring a minimum water absorption rate has been announced by *Rogers Corp.,* Manchester, Conn. The new product is Duroid 800.

One of a series of fibrous materials evolved by the company to bridge the gap between high quality insulating board and laminated phenolic, Duroid 800 is said to be physically stronger when wet than dry. It has a water moisture absorption rate substantially lower than 25% per 24-hr immersion and retains its dielectric strength under moist conditions. It is springy, rigid and homogeneous, designed primarily for flat punched insulating parts.

RX-429, a phenolic impact molding material with relatively high impact strength, has also been announced by Rogers Corp. The material can be automatically preformed on any standard tabletting machine, and preforms can be held to close tolerances. RX-429, which is said to have a fast rate of cure, can be compression, transfer or plunger molded. Typical properties include: apparent density, 38 (min); compressive strength, 22,000 psi (min); izod impact strength (milled notch in side), 0.8 ft-lb per in. of notch (min).

Metal Primer Prevents Rust

Gensco Chemical Div., General Steel Warehouse Co., 1830 N. Kostner Ave., Chicago 39, has announced a new chemical development in industry's fight against rust. Rustygon, a prime coat for metal surfaces, is a chemical that dissolves and prevents rust. No oil is used in its manufacture, and its coefficient of expansion and contraction being similar to metal, is said to permit it to move with the metal and avoid the cracking and blistering caused with ordinary oil base paints.

The primer can be applied with a rag, brush, spray or by merely dipping an object, and it penetrates all of the minute pits and surface irregularities, sealing off all of the rust and preventing future rust growth.

Surface coverage attained is approximately 1200 sq ft per gal, and it can stand several days prior to painting. It can be applied to wet as well as to dry surfaces with equal effectiveness; it dries quickly, and is generally ready for the final paint coat within an hour.

(More News on page 122)

From Bumper to Tailgate . . .

Reduces Deadweight and Increases Durability

N·A·X HIGH-TENSILE STEEL

The widespread use of N-A-X HIGH-TENSILE steel in transportation equipment emphasizes two vital characteristics of this high-strength low-alloy steel.

1. *Strength with less deadweight.* N-A-X HIGH-TENSILE steel reduces deadweight . . . of great importance in transportation equipment and military vehicles.

2. *Exceptional durability.* N-A-X HIGH-TENSILE steel, with its high strength and toughness, has proved greater resistance to fatigue and impact at normal and sub-zero temperatures. Its inherent structure and composition greatly reduce the effects of abrasion and corrosion.

The response of N-A-X HIGH-TENSILE steel to severe cold-forming operations and its excellent weldability by electric arc or resistance, atomic hydrogen or heliarc, and all other processes, are added important characteristics of N-A-X HIGH-TENSILE steel.

It's your SCRAP that makes your STEEL • • • Keep it moving to your scrap dealer

The "Eager Beaver"

The use of low-alloy, high-strength steels in military equipment assures longer life with less deadweight.

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division • Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION

New Materials and Equipment

Liquid Accelerator Gives High Physical Properties to Casting Resins

Casting resins can now be hardened without heat at room temperature in a matter of minutes, according to *Rezolin, Inc.*, 4825 W. Jefferson Blvd., Los Angeles 16, with their newly developed product, Quick-set.

The liquid accelerator is said to give much higher physical properties to casting resins than it has been possible to attain in previous types of quick-set accelerators. When added to their "8000" Tool-Plastic mix, the new formula is said to eliminate the use of ovens and overnight hardening. Control of hardening time desired is possible by increasing or decreasing the amount of the product used.

This duplicating pattern was made and ready for use in 1 hr and 43 min. by using the new Quick-set liquid accelerator formula.

Immersion Thermocouple Pyrometer for Molten Steel

Where shop men prefer a thermocouple pyrometer to measure steel bath temperatures in open hearths or electric furnaces, the new immersion thermocouple equipment announced by *Leeds & Northrup Co.*, 4934 Stenton Ave., Philadelphia 44, is said to offer exceptional operating convenience. The equipment consists of a platinum-platinum 10% rhodium immersion couple and a Speedomax pyrometer with special signalling features.

The thermocouple is mounted in a refractory-protected tube, supplied in lengths from 5 to 12 ft. Routine maintenance can be performed by the operator right at the furnace, and the fused silica protective tip can be replaced in a few seconds.

A set of three signal lights usually located near the furnace is operated by the Speedomax recorder. Speedomax

New Materials and Equipment

range, 2400 to 3200 F, spans the usual steel temperatures, while a separate section at the left edge of the chart covers 0 to 200 F, affording a check on room temperature to show thermocouple condition.

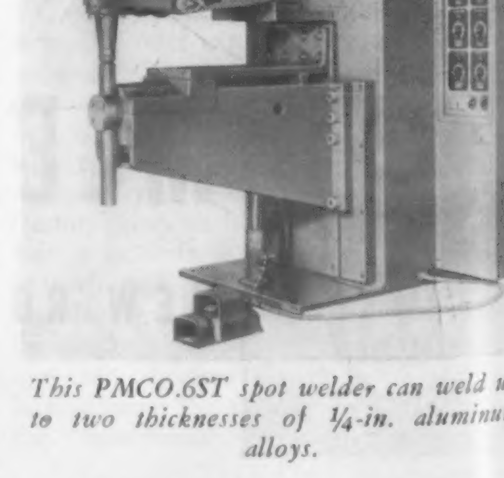
New Alloy Conserves Nickel

In line with the company's policy of conserving nickel supplies during the present emergency, *The International Nickel Co.*, 67 Wall St., New York 5, has announced the development of an alloy for use under conditions of high temperature and corrosion.

The new alloy, Incoloy, contains about 35 nickel and 20% chromium, with the balance iron. It is produced in most standard rolling mill forms, including sheet, strip, rod, wire and tubing. This alloy is designed for many purposes now served by some of the company's older alloys, which run up to more than 70% nickel.

Heavy Duty Spot Welder Joins Thick Aluminum

With an electrode force adjustable up to 23,000 lb and a rating of only 400 kva, the new spot welder offered by *Sciaky Brothers, Inc.*, Chicago, is said to be capable of exceeding the rigid requirements of the Air Force-Navy Aeronautical Speci-



This PMCO.6ST spot welder can weld up to two thicknesses of ¼-in. aluminum alloys.

New Materials and Equipment

fications AN-W-30 (MIL-6860) and AN-W-32 (MIL-6858).

Up to two thicknesses of ¼-in. aluminum alloys can now be spot welded with consistently high quality results on a heavy production basis. Extensive tests in company laboratories have indicated that the welds obtained on this material surpassed the MIL-6860 requirements in all respects.

Control functions and other features of the unit are described by the company as follows:

1. An extremely rapid rate of rise of the forging pressure is achieved through the use of a frictionless diaphragm pneumatic pressure system. Without leathers that rub against the walls of conventional cylinder head machines, friction is eliminated and quick follow-up pressure is assured.
2. A tailor-made wave shape, adjustable to suit any given spot welding application, is obtained by virtue of the Sciaky Three-phase, Modu-Wave System—thus eliminating the necessity of making prolonged compromises between current, timing and pressure sequence, as would be the case with conventional equipment.
3. The current conductance efficiency of the secondary circuit is vastly improved by the adaptation of solid electrolytic copper bars with sliding silver contacts at each terminal for transmitting the secondary current from the transformer to the movable electrode.

Phenolic Resin Permits Molding of Stronger Sand Cores

An improved liquid phenolic core binder resin especially formulated to meet critical foundry requirements has been developed by the Chemical Div., *General Electric Co.*, Pittsfield, Mass. Designated G-E 12353, the resin is said to permit the molding of stronger sand cores than was possible with former phenolic resins, and it has higher water diluteness and improved handling characteristics.

Other advantages offered by the resin are:

1. Baking cycles are reduced to about one-half the time required for conventional vegetable or petroleum-base core oils.
2. Provides less sand burn-in on the casting, and the excellent collapsibility and easy shakeout with the resin lessens the danger of casting breakage.
3. Low gas formation and high gas

MAGNESIUM

high machining speed means <u>more</u> pieces per hour!

When it comes to machinability, you can't beat magnesium! Generally, the maximum rate of machining speed is limited only by the maximum speed obtainable on modern machine tools. This, of course, means more pieces per hour and a sharp cut in production costs. One source reported a 50% reduction in machining costs over the metal previously used.

Another outstanding machining characteristic of magnesium alloys is their ability to take an extremely fine finish. Surface smoothness readings of three to five micro-inches have been reported for finish-turned magnesium. Finish-grinding operations required on other metals usually can be eliminated.

Cutting tools designed for steel or brass may be used, but to take full advantage of magnesium's machinability, tool design should be slightly modified. It is suggested that relief angles be increased and clearance angles made larger to provide greater chip space.

Dow has over 30 years of experience in magnesium—a call to your nearest Dow sales office will put this knowledge at your disposal.

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Dow Chemical of Canada, Limited, Toronto, Canada

DOW

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New Materials and Equipment

permeability result in sounder and smoother castings.

When used, G-E 12353 is first mixed with water and then mulled thoroughly with sand. After ramming or blowing the treated sand into core boxes, the molded core is removed and baked. Following baking at a temperature of about 375 F, the core is ready for the pouring operation. For most applications, 0.5% resin weight to sand weight is sufficient.

The resin can also be used as a spray when diluted with four parts of water to increase the hardness of oil or resin bonded cores. The spray penetrates cores to a depth of about ⅛ in., and the hard shell which results is said to resist penetration of metal and also protect the cores from breakage in handling.

Ultrasonic Flaw Detector

Developed originally for testing railroad rail in track, the new ultrasonic flaw detector currently offered by *Branson Instruments, Inc.*, 430 Fairfield Ave., Stamford, Conn., can also be used to test certain other steel and aluminum parts with uniform cross sections.

In operation, the instrument is turned on by a micro-switch in the handle; all other controls are set prior to testing, as no adjustment is required. The X-cut quartz crystal transducer is swivel-mounted and is said to remain in contact with the rail despite accidental tilt of the handle. Continuous sections of rail can be checked easily by sliding the head along the top of the rail, since a wear

Power is supplied this ultrasonic flaw detector by batteries contained in the instrument case.

- Generous Sized Cabinets
- Conditioned Cooling System
- Built-In Checklite System
- Oversized Components
- Filament Voltage Regulation
- Industrial Type Tubes

Durable industrial type tubes—shortened and strengthened internal structure for greater mechanical strength — Kovar metal-to-glass seals to withstand greater thermal shock.

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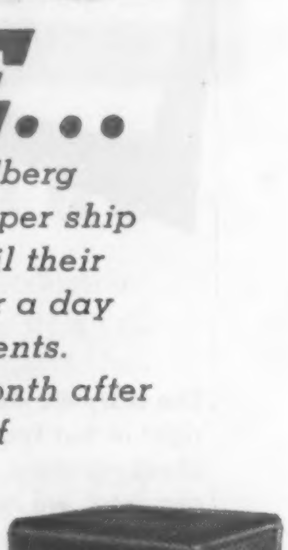
Rugged . . . durable . . . and dependable! Lindberg Induction Heating Units are built like the clipper ship captains of old, who had to be iron men to sail their wooden ships. They give dependable 24 hour a day service under heavy production line requirements. Designed for service . . . day after day . . . month after month . . . far beyond the usual capabilities of Induction heating equipment.

For fast, accurate, versatile selective hardening—controlled in both depth of penetration and area covered—investigate the Lindberg Induction Heating Units. Performance records from plants throughout the nation show 24 hour a day operation—day after day—month after month. Ask for Bulletin 2451.



LINDBERG HIGH FREQUENCY DIVISION

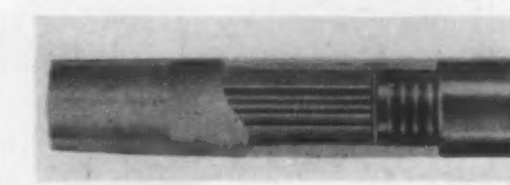
Lindberg Engineering Company, 2450 W. Hubbard Street, Chicago 12, Illinois

plate protects the silver-plated quartz transducer. Eight hundred to 1000 test locations per day can be checked, according to the manufacturer.

Housed in a waterproof canvas carrying case, this portable detector weighs only 12lb.

Cap Electrode Conserves Critical Copper Alloy

P. R. Mallory & Co., Inc., Indianapolis, Ind., has announced a new cap electrode, claimed to reduce electrode costs without any sacrifice in performance, and to conserve critical copper alloy. Called Nu-Wrinkle Cap Electrode, it consists of a reusable shank and a replaceable cap, the cap being relatively small and inexpensive in comparison with the conventional one-piece electrode. When the welding face of the cap electrode is no longer serviceable, it is necessary only to replace the small, inexpensive cap still using the same shank.



This cap electrode is a readily replaceable insert for resistance welding dies.

A corrugated skirt provides positive electrical and thermal contact with the shank, while the fluted water hole in the shank assures maximum cooling efficiency.

Corrosion Inhibitor

A new approach to the prevention of corrosion is currently being offered by *Organic Products Co.*, Irving, Tex. Cor-in offers a method of preventing corrosion that does not call for any organic or oily coating. It acts as a neutralizer and thus destroys the corrosiveness of all moisture or water vapor that comes in contact with it.

Supplied as a solution of active materials in organic solvents, it is applied by brush, spray or dip. The solvents are said to evaporate rapidly, leaving a loosely adhering film of crystals which vaporize very slowly into surrounding air until the air is saturated with this vapor. When moisture vapor comes in contact with the vapors of Cor-in, they are claimed to be made noncorrosive. This continues until all the crystals have been vaporized and

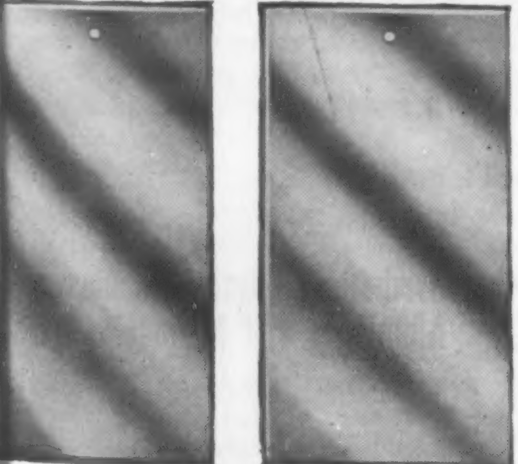
New Materials and Equipment

Clear Coatings for Zinc and Steel Stand 800 Hours' Salt Spray

Increased use of zinc die castings and of zinc-plated steel to replace unavailable materials, combined with the tight supply of copper, nickel and chromium normally used for plating zinc, has focused attention on surface coatings comparable to plating in service performance. Unbiased laboratory tests show that at least two of the clear finishes in the company's line withstand the exceptionally long period of 800 hours' exposure to salt spray and to weatherometer tests.

Effectively protect zinc

These tests demonstrate that DULAC Clear Universal Lacquer #462 and CODUR Clear Synthetic Y743 provide completely satisfactory protection on zinc, zinc plated steel and steel. Even after the unusually severe tests to which these finishes were subjected, there was no indication whatever either of failure of the coating or of discoloration of the zinc.



(Left) A zinc-plated steel panel newly coated with DULAC #462. (Right) A similar panel after 800 hours' exposure to salt spray, showing no evidence of attack on the finish.

Adaptability to Drying Schedules

While both finishes give the same performance, DULAC #462 is an air-drying coating, while CODUR Y743 is a baking type. This permits choice of the correct finish to fit into the drying schedules of a particular finishing room.

Technical Data Bulletin #110 on clear finishes is available from Maas & Waldstein Co., 430 Riverside Avenue, Newark 4, N. J. On request, M & W Technical Service Engineers will discuss specific problems.

(Adv.)

New Materials and Equipment

used up in neutralizing moisture vapor, or lost in air circulation.

Applications for the new inhibitor are said to include: die-making, hand tools, cutting tools, work in process and parts for shipment and storage.

Synthetic Rubber Sealer

An extruded synthetic rubber sealer first used in automobile manufacturing has been made available to industry by the Adhesives and Coatings Div., *Minnesota Mining and Manufacturing Co.,* 411 Piquette Ave., Detroit 2.

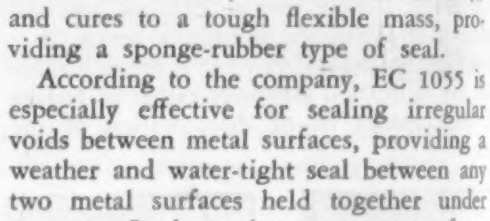
Extruded in rope-like dimensions, in varying shapes and lengths for different production lines, the sealer, when pressed into a seam and tightened between metal surfaces, seals the joint like a rubber gasket. When heated, it swells about 50% and cures to a tough flexible mass, providing a sponge-rubber type of seal.

According to the company, EC 1055 is especially effective for sealing irregular voids between metal surfaces, providing a weather and water-tight seal between any two metal surfaces held together under pressure. It also resists temperatures from —70 to 200 F, and presents no fire or toxicity problem.

Improved Die Casting Machines for Aluminum and Magnesium

Reed-Prentice Corp., 677 Cambridge St., Worcester 4, Mass., has announced significant design changes in Models 1½G and 2G die casting machines which are said to assure more successful die casting of aluminum and magnesium parts.

A greatly improved shot plunger is one of the features provided. Plunger speed of 10,000 in. per min—required especially for magnesium die casting—is said



A greatly improved shot plunger on this die casting machine is said to assure better results in die casting aluminum and magnesium parts.

New Materials and Equipment

to be attained through a 3-in. two-way valve built integral with the shot cylinder and by incorporating a special prefill arrangement. With this arrangement, the plunger moves at low pressure until the mold is filled, at which time maximum pressure is applied instantaneously to produce more perfect castings.

The Model 1½G machine develops 250 tons die locking pressure and die casts aluminum parts weighing up to 3.75 lb and magnesium parts up to 2.4 lb; while the Model 2G machine is claimed to provide 400 tons clamping pressure and has a shot capacity of 9 lb aluminum and 6 lb magnesium. Both units have 4 tie-bar construction and a sliding support bracket for the movable die plate to maintain proper die alignment under continuous operation.

New Chromate Coating Process for Zinc and Cadmium

Development of a new, simplified process for producing chromate coatings on both zinc and cadmium has recently been announced by *Enthone, Inc.*, Dept. MA, 442 Elm St., New Haven, Conn. Applicable for both zinc plate and zinc-base die castings, the process is said to offer low cost and ease of operation.

In operation, from 1 to 2 oz of salts are used per gallon of water, and after immersion for a few seconds at room temperature, an adherent chromate coating is produced.

The coatings produced are said to meet all existing specifications referring to chromate coatings on zinc and cadmium. Salt spray resistance on zinc plate are over 200 hr and on cadmium plate are over 500 hr. Various colors can also be applied to the coatings by means of suitable dyes. Jet black, red and several other shades can be achieved.

Resistance Spot Welding and Soldering Machine Cuts Production Costs

Availability of a new resistance spot welding and soldering machine (Model 1000 WV, or 2000 WV-a.c. only) equipped with timer, has been announced by *Joyal Products, Inc.*, 56 Belmont Ave., Newark 3. The unit is said to speed production, cut costs, eliminate shrinkage in the manufacture of instruments, and is

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King FIFTH WHEEL COMPANY
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New Materials and Equipment

invaluable to the manufacturer of small products and jewelry.

Another advantage offered by the machine is that it silver solders, soft solders and spot welds dissimilar metals. It spot welds steel parts up to 3/32 in. in thick-

This resistance spot welding and soldering machine can be furnished with a Bakelite work table and all verticle electrode machines at extra cost.

ness and will solder brass up to 1/8 in. in thickness as well as sterling silver and other precious metals.

Especially effective in soldering additional elements to an assembly, the machine leaves no pitting marks. It is particularly applicable to the assembly of fine parts in jewelry, instruments and electronic components—also for spot welding ferrous and nonferrous metals.

Spindle Sander and Grinder

According to *Kindt-Collins Co.,* 12651 Elmwood Ave., Cleveland 11, their new Master spindle sander and grinder for wood, metal and plastics is the only one of its type that has a tilting spindle rather than a tilting table. The job on which the operator works is always in a horizontal position and the master spindle can be used oscillating or nonoscillating, can be tilted from 0 to 45 degrees by a worm and gear unit, and can be securely locked in place at any desired position.

Another exclusive feature claimed for the unit is the core box attachment, which produces straight and tapered core boxes mechanically, eliminating tedious handwork and materially reducing the time involved.

Additional advantages include: a lighted periscope for easy reading of settings; a 2-hp constant horsepower motor, with choice of 2000 and 4000 rpm speeds;

(Continued on page 139)

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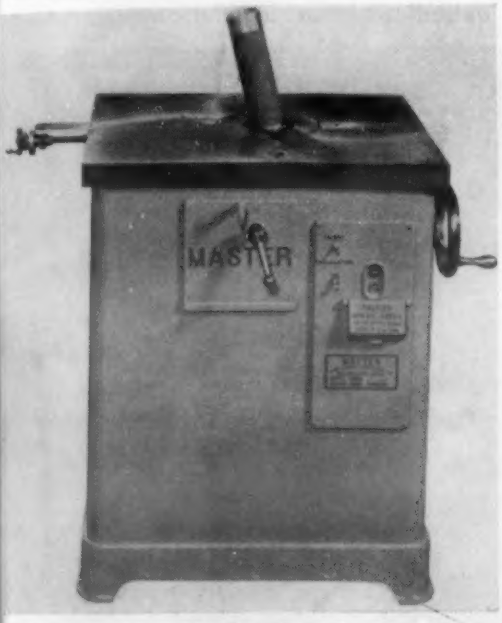
adaptability of abrasive sleeves from 1/4 to 4 in. in dia, and 6 to 11 in. in length; also grinding wheels up to 5 in. in dia and 5 in. high.



This sander and grinder has a tilting spindle rather than a tilting table.

Bonding Adhesive

A new rubber-to-metal bonding adhesive offered by the Plastics Div., *Ciba Co., Inc.*, 627 Greenwich St., New York 14, is said to eliminate costly, time-consuming pre-processing of aluminum and magnesium surfaces in rubber-to-metal bonding operations.

Ardux 120 makes it possible to brush coat the metal and rubber surfaces (both natural and synthetic types) to be bonded with the mixture; apply a pressure of about 10 to 20 psi for 15 to 20 min. at 110 to 120 C or for 5 min. at 140 to 150 C, and achieve a firm durable bond.

Rubber can also be bonded with Ardux 120 to most plastics with comparable excellent results.

New Broaching Procedure

For accelerated production of Turbo-super-charger wheels and mating blades, the *Lapointe Machine Tool Co.*, Hudson, Mass., has developed a broaching procedure based on its single ram vertical broaching machine.

The company handles both jobs on a 15-ton, 90-in. stroke machine through the use of interchangeable fixtures. The wheel fixture embodies completely automatic indexing and hydraulic clamping. Blades are broached two at a time—the first

New Materials and Equipment

blade being rough broached, and the second one finished broached at the same stroke of the machine.

Based on 80% efficiency, the time required for broaching the complete wheel,

These blades are broached from bar stock, Timken Alloy 16-25-6.

with 32 pine-tree slots, is said to be 65 min. The blades are broached at a speed of 60 finished blades per hr. Very close tolerances are maintained—within 0.0005 to 0.0007 in.

General Purpose Pyrometer for Rapid Readings

A new, general purpose, low-temperature model, portable pyrometer which is a self-contained instrument for rapid temperature determination below 800 F has been announced by *Claud S. Gordon Co.*, 3000 S. Wallace St., Chicago 20.

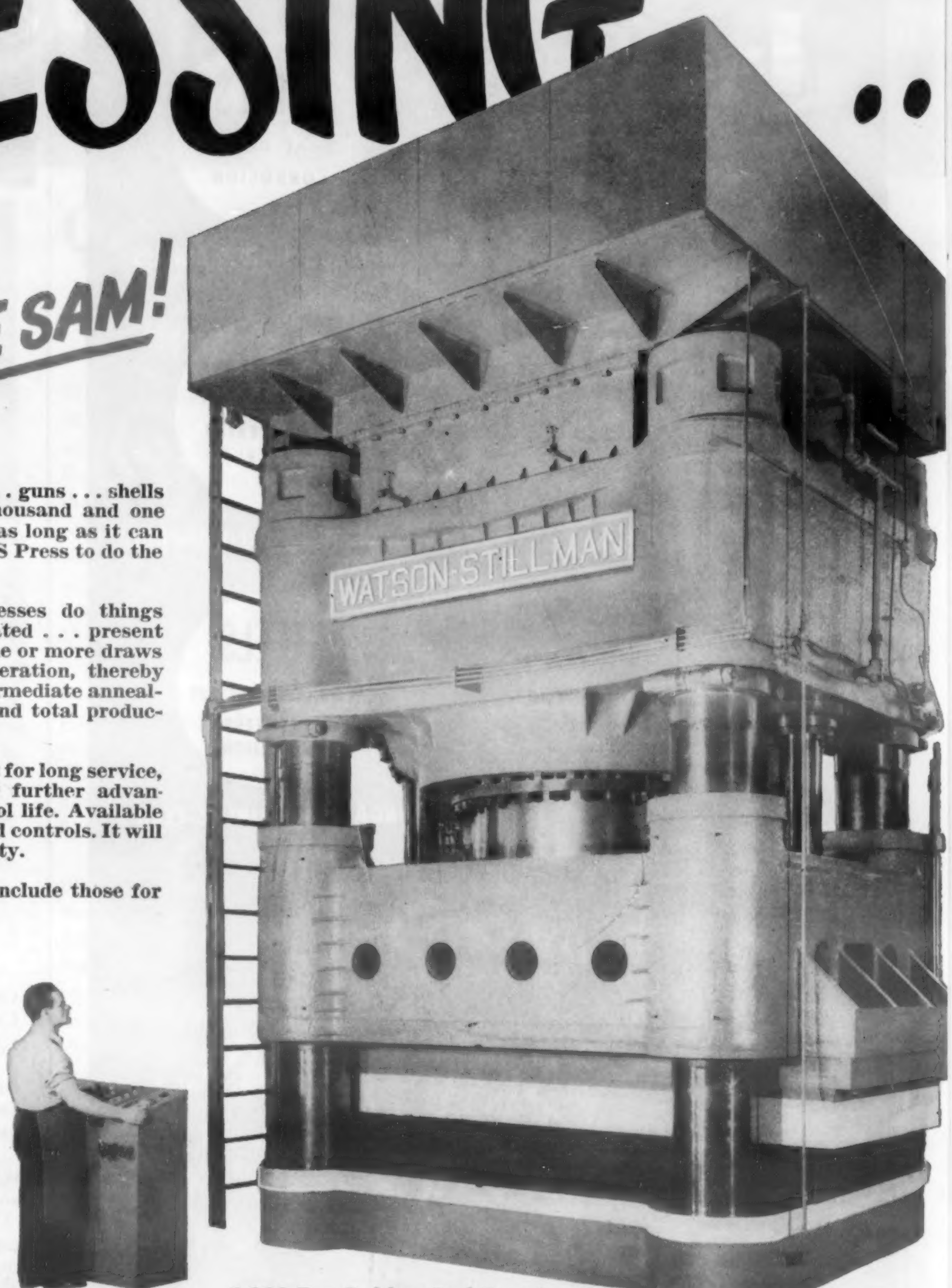
Precision built, the meter is enclosed in a finished well balanced metal case with a double-strength glass window. An integral, easy-grip handle makes it convenient to use in any position. The instrument is claimed to be of the high-internal resistance type for accuracy, while a choice of four calibrations allows the most effective use of the scale range.

Available for use with the instrument are two needle thermocouples, a ribbon thermocouple, a surface tip thermocouple, and other specially designed thermocouples and extension arms. These are readily interchangeable and, without any adjustments or recalibration of the instru-

PRESSING . .

out the

ARMS for UNCLE SAM!



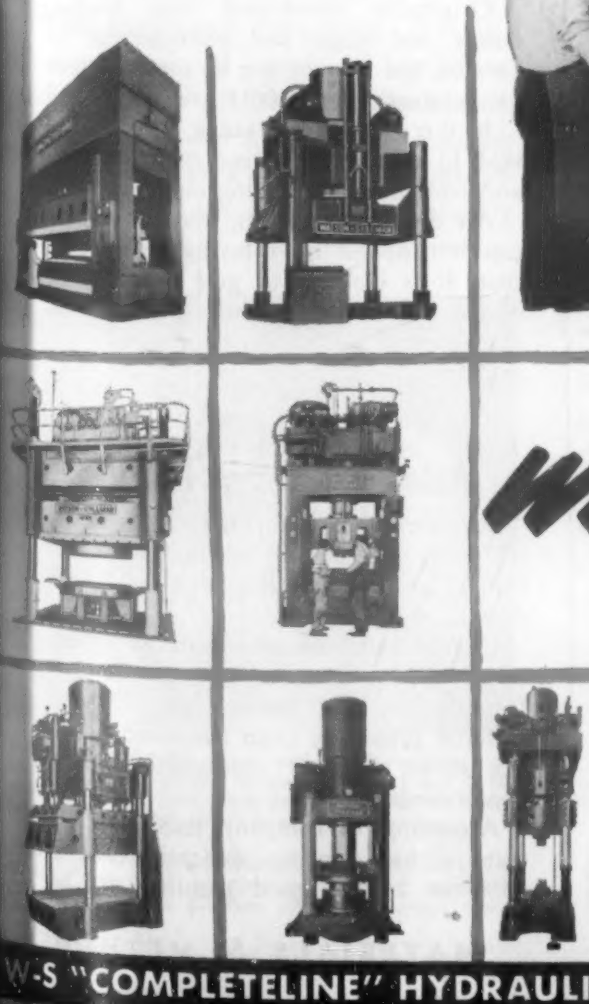
Planes . . . tanks . . . guns . . . shells . . . shell cases or any one of a thousand and one other items that must be produced, as long as it can be pressed out of metal, there's a W-S Press to do the job . . . and more economically, too.

W-S Medium and Deep Draw Presses do things faster. Rejects are virtually eliminated . . . present dies and materials can be used . . . one or more draws may be cut from a progressive operation, thereby saving man hours on the job . . . intermediate annealing is often reduced or eliminated and total production time cut down.

Designed for precision work and built for long service, these W-S Hydraulic Presses offer further advantages in set-up, maintenance and tool life. Available in a large choice of pumping units and controls. It will pay you to investigate their flexibility.

Other W-S Metal Working Presses include those for Forming, Flanging, Trimming, Forging, Coining, Hobbing, Extruding, Briquetting, Bending and Straightening.

5,000 Ton Rubber Pad Forming Press



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W-S "COMPLETELINE" HYDRAULICS . . . THE SHORTEST DISTANCE FROM PRODUCTION TO PROFIT

New Materials and Equipment

ment, quickly readies it for measuring the surface temperature of stationary and revolving rolls, flat and irregular surfaces of molds, dies, etc., in rubber and paper making, plastic materials, rubber, wax, oils, greases, and other semi-fluid materials.

The compact design of the pyrometer makes it ideal for field service, laboratory and production-line service.

Heat Resistant Lacquer

A new one-coat, heat resistant lacquer, C 5173, has been introduced by the *United Lacquer Manufacturing Corp.,* 1001 W. Elizabeth Ave., Linden, N. J.

Originally developed for finishing lamps and stage and photographic apparatus, the lacquer can be used wherever temperatures up to 300 F are encountered.

In this temperature range the lacquer is said to provide excellent color retention and resistance to cracking or peeling.

Air drying in 15 min., the new coating can be applied by spraying in a single coat. It is claimed to give excellent adhesion to all metals, including steel and aluminum.

Asbestos-Neoprene Material

A material that is highly resistant to oil, water and gasoline has been developed for gasket use by *Rogers Corp.,* Manchester, Conn.

Duroid 3102, an asbestos-neoprene material, is the latest of a new group of formulations that blanket the range of material properties from laminated phenolics down through vulcanized fibre to paperboards.

According to company tests, the new material has a water absorption rate of 15% in 24 hr, good gasoline and oil

New Materials and Equipment

resistance plus excellent flexibility, and a bursting strength of 500 psi.

Recommended for use at temperatures under 300 F, Duroid 3102 is supplied in thicknesses ranging from 0.031 to 0.125 in. in fabricated form.

Cleaning and Phosphatizing Compound

The Dubois Co., Cincinnati 3, has announced a new cleaning and phosphatizing compound, Ion-Kote, designed to prepare steel and other metals for painting.

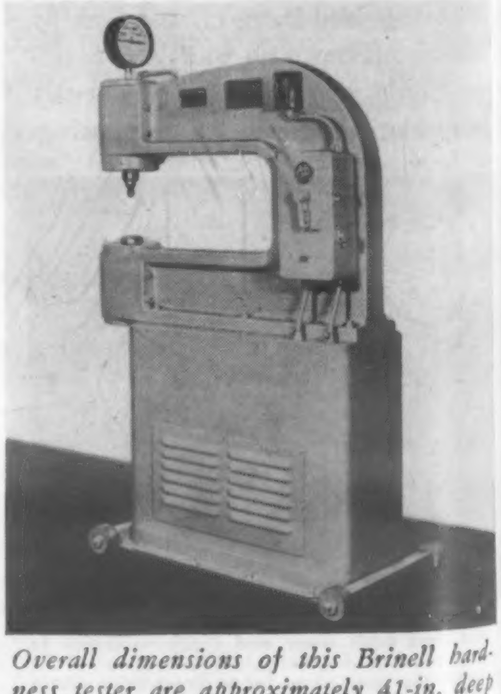
A white, granular, easy to handle dustless powder, the compound is used in spray washers prior to painting It deposits a hard, dust-free, phosphate coating on metal which is said to prevent rusting and increase adherence.

Another advantage claimed for the compound is that parts coated with it are able to withstand more than 500 hr of salt spray testing.

Hardness Testing Machine Has Deep Throat

A newly designed Brinell hardness testing machine which is said to incorporate a throat depth of 24 in. has been announced by *Steel City Testing Machines, Inc.*, 8843 Livernois, Detroit 4.

Designated Model AP-1, the C-frame machine offers several unusual features. It is mounted on wheels so that it can be



Overall dimensions of this Brinell hardness tester are approximately 41-in. deep and 19-in. wide. Height depends on anvil height specified.

New Materials and Equipment

rolled out of the way when not in use and then easily rolled into position, reaching out over a conveyor, the lower anvil is the top of a hydraulic piston which rises as the load is applied to take the pressure off the conveyor; machines are made to order so that anvil height will conform to customer's conveyor height, and the maximum vertical opening between ball penetrator and anvil is 4 in.

In operation, the cycle is controlled by a snap switch mounted on the side of the machine. When on, the switch applies the 3000 kilogram load; when off, it releases the load.

New Molding Material for Mock-ups and Prototypes

Currently developing substantial interest among design and production departments for the purpose of producing mock-up and prototype parts and assemblies, a new and useful material for the plastics industry is now available from the *Industrial Products Div., Clopay Corp.*, Clopay Sq., Cincinnati 14.

Identified as Closeal, and supplied as a putty-like molding material similar to modeling clay, the new product can be molded by hand to form any desired shape, after which it can be baked at temperatures in the vicinity of 350 F to produce a model in permanent form. Prior to the baking operation, Closeal is uniformly soft and workable, but after the baking operation, it is converted to either a hard rigid material or to a soft form having a Durometer in the vicinity of 50 (Shore A).

New Soak Solvent Acts Quickly

Designed specifically for the quick removal of buffing and drawing compounds from knurled or fluted surfaces of all metals, the new solvent offered by *Du-Lite Chemical Corp.*, Middletown, Conn., is said to remove all types of soils in less than a minute.

Dynakleen requires no heating or special tanks, and can be used in spray washing machines or applied by hand. It is a safety solvent which dries quickly and can be used over and over with only occasional filtration.

Another advantage claimed for the solvent is that it is an ideal conditioner for preparing metal surfaces prior to plating, painting, parkerizing, bonderizing and galvanizing.

Three Vinyl Formulations Widen Applications of These Resins

by KENNETH ROSE,

Western Editor, Materials & Methods

● SEVERAL NEW FORMULATIONS of vinyl resins developed by B. F. Goodrich Chemical Co. widen the application possibilities of these versatile resins. The first is a polyvinyl chloride intended for standard formulation with plasticizers, pigments, fillers, and the like, and has ease of processing as its feature. The second is a polyvinyl chloride also, with excellent clarity, heat stability and good strength, and is intended for rigid or semirigid uses. A vinyl chloride-vinylidene chloride copolymer that is directly soluble in such organic solvents as toluene, xylene, and other aromatics is the third, and it is expected to put the vinyls into many kinds of solution coatings applications.

The relatively new process of powder mixing offers an advantage to the molder and extruder in (1) use of simple equipment, (2) lower inventory of materials, and (3) simplified color matching. The easy processing resin, offered under the trade designation Geon 101-EP, fits in with this method by readily absorbing most plasticizers at temperatures of about 200 to 240 F to produce dry molding powders. Electrical properties are close to those of the standard polyvinyl chlorides, indicating its possibilities as an insulator. Some of these are:

Insulation resistance, megohms/1000 ft	4750
Dielectric constant	6.00
Power factor, %	8.00

The easy processing polyvinyl chloride is a high-molecular-weight

(Continued on page 150)

"Sterling" example
of SPEED NUT savings...
56c per unit...80% assembly time

Sterling supplies new meters with Push-On SPEED NUTS—Mallory does assembly job 5 times faster—saves 56c per unit, according to letter from Mr. H. K. Mallory, Mgr. Rectifier Division, P. R. Mallory, Inc., to Mr. J. R. Clark of the Sterling Manufacturing Co., Cleveland.

"We have been using the Tinnerman Push-On fastener, as supplied with your Sterling meters, in our 6RS10 units for over a year now.

"We are very pleased with this new mounting means for your meters, especially because we were somewhat instrumental in your adopting it. Recent cost comparisons show that *assembly of the meter with the Tinnerman fastener proved to be five times as fast as the old ring clamp you used to provide . . . with a total savings of 56 cents per 6RS10 to us."*

In the closing paragraph Mr. Mallory said: "Shows what can be done by using a little ingenuity in the solving of a problem." We certainly agree. Fastener ingenuity is our stock in trade . . . perhaps it can be applied to your problems. Call on your Tinnerman representative soon—and write for new "Savings Stories" edition. TINNERMAN PRODUCTS, INC., Dept. 12, Box 6688, Cleveland 1, Ohio. In Canada: Dominion Fasteners Ltd., Hamilton. In Great Britain: Simmonds Aerocessories, Ltd., Treforest, Wales.

Three Vinyl Formulations

continued from page 148

resin, with the stability and physical properties associated with high molecular weight. Savings in mixing time of 25 to 50% are reported. When properly plasticized, the material is suitable for such articles as belts, trim for shoes, wire insulation, and handbags. Here the higher molecular weight permits increasing the percentage of plasticizer when flexibility is the important property. Extrusions may frequently be run at a temperature 20 to 30 F below that of standard vinyl resins. Calendering, and injection and compression molding, will usually show an advantage in either lowered processing temperature or higher rate of production.

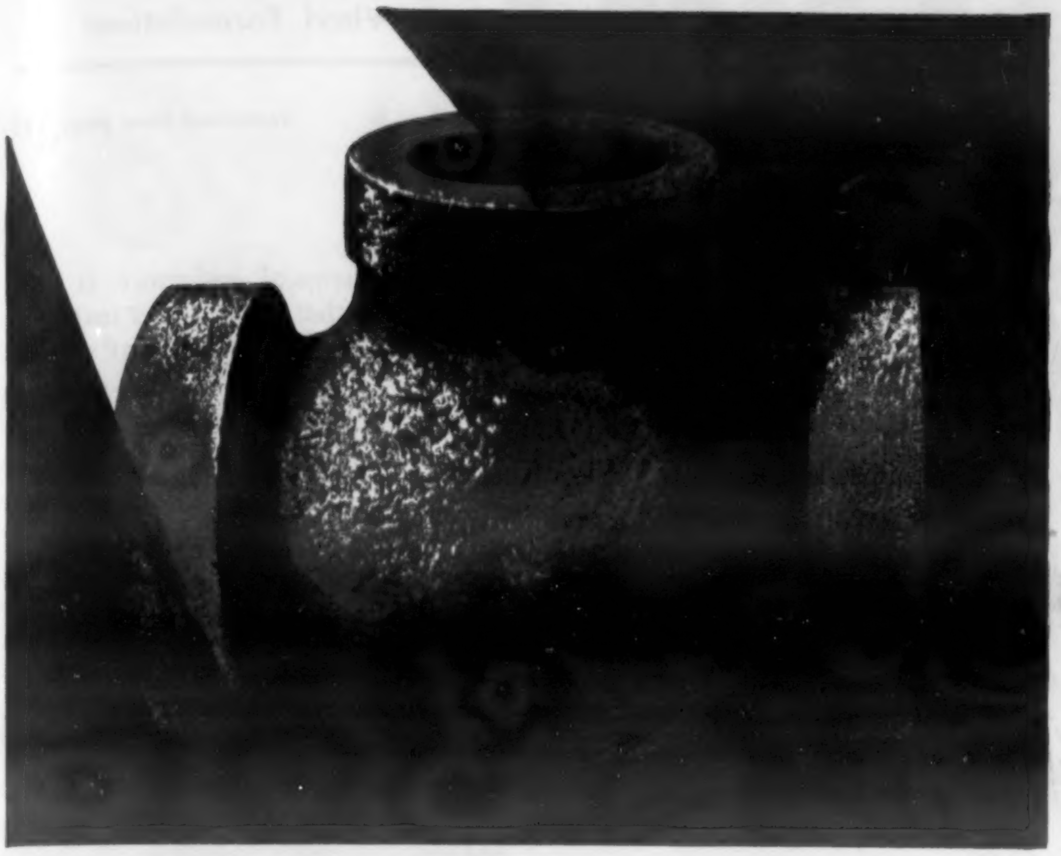
The second modification of polyvinyl resin produces a material that has high thermoplasticity without the addition of a plasticizer. It can be molded, calendered, or extruded without special formulation, and so is suitable for fabricating into rigid parts. This will bring the new formulation into the field in which the polystyrenes, the cellulosics and the acrylics among the thermoplastics, and the phenolics, melamines and

Unbreakable phonograph record molded from polyvinyl chloride will not break, chip or crack, and has exceptional tone fidelity, particularly in the high frequency range.

ureas among the thermosets, have been the important materials.

Producers of the new formulation point out that polyvinyl chloride has excellent inherent properties to recommend its use in the field of rigid parts. It is nonflammable in itself, and burns only when a combustible plasticizer has been added to the formulation. Electrical properties are excellent. Impact resistance and abrasion resistance are superior to those of most of the materials in this

(Continued on page 152)



whats this . . . a subversive casting?

Castings, like people, can prove to be unsound . . . dangerous. And the concealed faults in either are difficult to detect until the damage is done.

Manufacturers who insist upon sound steel castings know from long experience that they can depend on Sivyer. The most rigid metallurgical control . . . every known scientific test . . . combine to assure the internal integrity of Sivyer Castings. The result . . . longer service life, extra dependability, under the toughest conditions.

You don't need a congressional investigation to get rid of subversive castings in your operation. Look for the famous Sivyer (S) which guarantees a 100% dependable steel casting.

SIVYER

SPECIALISTS IN HIGH ALLOY AND SPECIFICATION STEEL CASTINGS

SIVYER STEEL CASTING COMPANY • MILWAUKEE • CHICAGO

Three Vinyl Formulations

continued from page 150

group. Chemical resistance is also better than that of the other materials suitable for rigid molded parts.

The greatest difficulty in the way of the vinyls entering the rigid parts field heretofore has been their poor processing qualities as compared with the polystyrenes or the cellulosics, for example. The new material can be molded without addition of plasticizer at temperatures below about 300 F, according to its producers.

The primary use of vinyl chloride-vinylidene copolymer is in paints and lacquers. Shown here is a test panel being sprayed for test purposes.

Heat stability is good, and the materials may be produced in crystal clear grades when desired.

An interesting possibility for the new formulation is in the manufacture of unbreakable phonograph records. It has good strength, high resistance to cold flow, and good abrasion resistance in addition to its superior moldability. Tests made have shown high fidelity, particularly in the upper ranges of sound. Clear piping for the chemical industry is another potential use. Its solubility in mixtures of acetone and aromatic solvents holds out the possibility of use in the manufacture of adhesives and coatings. It will sell for about 34¢ per lb.

Some of the most important properties of the new vinyl in the unplasticized condition are:

Tensile strength, psi	6600
Hardness, Durometer D	82

(Continued on page 154)

±.004? ±.002? ±.001?

Whatever the tolerances you need, we can work within them!

PROLON PRECISION-MOLDED relay assemblies for I. B. M. Tolerance limitations ±.001. "Hycar", a rubber phenolic with excellent shock resistance, provides necessary strength with sufficient resiliency to hold breakage to a minimum. "Durez" lends dimentional stability.

We have the experience, the facilities, the skill to turn out intricate, accurate moldings. During World War II, for example, Prolon made plastic parts for the Proximity Fuse, a job requiring skilled precision molding. Continuously for the past 10 years, we have been producing battery cases for use in Air Force planes.

Today, *as of now*, we are ready to go right into production on other defense projects. No waiting period for training personnel and adapting facilities! We have room to expand, if desired, and unlimited power is available. Our engineering department has the technical and practical experience necessary to advise on designs, on correct choice of plastic materials, on efficient molding methods, compression or injection. We make our own molds.

Whether your requirements are defense or civilian production, a letter, a wire, or a telephone call will bring one of our planning engineers to your office. No obligation.

PLANNING · DESIGNING · DIE MAKING · MOLDING
FOR CIVILIAN OR DEFENSE PRODUCTION

THERE IS
NO SUBSTITUTE
FOR PLASTICS

PROLON
PLASTICS

PROLON PLASTICS, A DIVISION OF PRO-PHY-LAC-TIC BRUSH COMPANY, FLORENCE, MASS.

continued from page 152

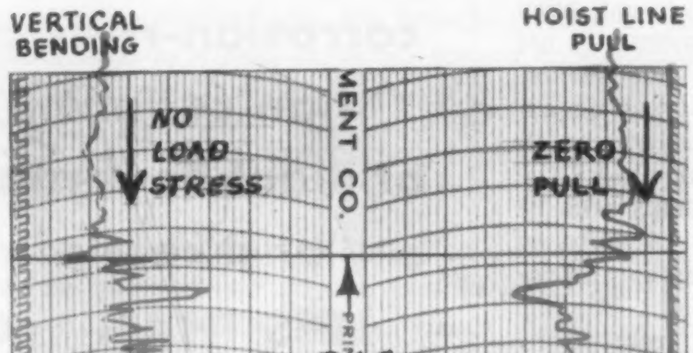
Distortion under load, 0.1-in. drop	140 F
Specific gravity	1.39
Izod impact strength, lb/in.	0.50
Water absorption, 24 hr, %	0.14

A vinyl-vinylidene chloride copolymer seems to have its greatest potentialities in the field of solution coatings. It is soluble at room temperature in such aromatic hydrocarbons as toluene and xylene, and the solutions are stable, even at high concentrations and when cooled to 32 F. The solutions become viscous at the lower temperatures, but recover their fluidity without gelling when warmed to normal room temperature.

As a coating material for such metals as aluminum, copper, lead, tinplate and steel, the resin contributes good chemical and water resistance, flame resistance unless plasticized with a flammable plasticizer, good abrasion resistance, and good adhesion to the metal. One possibility here is its use as a component in can lining lacquers. In the wrappings field the resin, used as a coating over paper, metallic foils and cellophane, provides a moisture barrier in some cases, and makes the material heat-sealing. Labels and cover stock are other possibilities in the paper coatings field. Coatings on a fabric base might find application in flameproof window shades, tents or awnings; decorative enamels for use on rubber would find its abrasion resistance valuable. Printing inks might be formulated with the soluble resin to improve adhesion and chemical resistance. The paint and lacquer industry generally will probably give the new material consideration in the formulation of fireproof sprayable lacquers.

Coatings can be applied by any of the standard methods, such as brushing, spraying, roller coating, and knife or bar coating. Solutions ranging to 50% total solids can be prepared by agitation of the resin in the solvent at room temperature.

In addition to its possibilities in the coatings field, the material is of interest to producers of unsupported films. Films can be cast from the solutions to form thin stock of flexibility determined by the type and amount of plasticizer added. Even the unplasticized film possesses a degree of flexibility that is sufficient for many applications.



Put it in writing with a

BRUSH RECORDING ANALYZER

strain analysis improves design...

BRUSH ANALYZER GIVES COMPLETE DATA... IN WRITING

● If the boom on an excavator is "over-designed", needless weight is added and steel is wasted. If the boom is "under-designed", failure may result.

That's why designers of the Marion Power Shovel Company get design facts from excavators in actual operation. With strain gages mounted on the boom, the hoist line pull on the shovel and the vertical bending of the boom are recorded automatically with a Brush two-channel Recording Analyzer. Event markers, recording on the same graph, indicate comparative rpm of different shafts.

Result—data not previously known has led to an improved design of Marion Excavators, and the saving of weight in the booms. Despite the severe operating conditions—for instruments—the Brush Analyzer continues to give satisfactory service.

It will pay you to investigate Brush Analyzers for studies of strains, displacements, light intensities, temperatures, surfaces, d-c or a-c voltages or currents, and other static or dynamic conditions. Write for full information. The Brush Development Company, Department G-13, 3405 Perkins Avenue, Cleveland 14, Ohio, U. S. A. *Canadian Representatives:* A. C. Wickman (Canada) Ltd., P. O. Box 9, Station N, Toronto 14, Ontario.

THE Brush DEVELOPMENT COMPANY

PIEZOELECTRIC CRYSTALS AND CERAMICS • MAGNETIC RECORDING • ELECTROACOUSTICS • ULTRASONICS • INDUSTRIAL & RESEARCH INSTRUMENTS

News Digest

Metallized Steel

(continued from page 13)

aluminum under exposure to different atmospheres. Duplicate steel specimens will be sprayed with aluminum and zinc coatings varying in thickness from 0.003 in. to 0.015 in. with and without vinyl cover coats.

Preparation of the more than 4000 specimens to be exposed is already underway. When the specimens are completed early this fall, they will be assembled for exposure at such standard corrosion test sites as those located at Kure Beach, N. C.; Point Reyes, Calif.; Gulf Coast; New York City; and Wrightsville Beach, N. C. Exposure will be for periods of one, three, six and 12 years.

The test program is intended to provide authoritative data on what thickness of zinc or aluminum to use for different exposures for various lengths of time. The types of exposure include sea water, marine atmosphere and different industrial atmospheres. Arrangements will be made for examination of exposed specimens at regular intervals and for issuance of periodic reports. Anyone interested in securing a copy of the program or progress reports when issued may write to the Secretary, AWS Committee on Metallizing, American Welding Society, 33 W. 39th St., New York 18.

Determination of Magnesium in Cast Iron

Addition of small amounts of magnesium to cast iron has received increasing attention recently because it imparts desirable ductile qualities to the iron, apparently by producing a nodular or spheroidal graphite structure. Because a variable part of the added magnesium is lost during the production of the cast iron, the final magnesium content must be determined by chemical or spectrographic analysis. Although spectrographic methods are quicker for routine examination, a suitable chemical method is needed, both for checking spectrographic standards and for use in laboratories not equipped for spectrochemical methods. An answer to this need is offered by a

Let TYGON PLASTIC
provide the answer to your TOUGH CORROSION PROBLEMS

Tygon Plastics are resistant to an unusually wide range of corrosives, much more so than rubber or metals. Many formulations are completely non-toxic, may be used safely in contact with foods, drugs or solutions which must be kept free from metal or sulphur pick-up.

Tygon's physical properties are interesting, too. Tygon, in liquid form, can be applied like a paint to metal or concrete; dries to a tough, elastic film that shrugs off corrosive fumes or acid spillage. Solves the problem of protecting structural steel, tanks and other exterior surfaces.

Tygon sheet stocks, 3/32″ thick, serve as an effective long-lived lining for tanks, ducts, pipe and other process equipment, particularly for handling strong oxidizing agents such as nitric, chromic, strong concentrations of sulphuric acids, and bleaches.

Tygon cut, molded, and extruded gaskets further extend the range of usefulness of this versatile material.

Tygon flexible plastic Tubing offers a better, simpler way to pipe many corrosive solutions, and gases, as well as liquid foods, and beverages. Available in bores from .120″ up to 2″, Tygon Tubing may be clear or opaque, as well as outer-braid reinforced for high pressures.

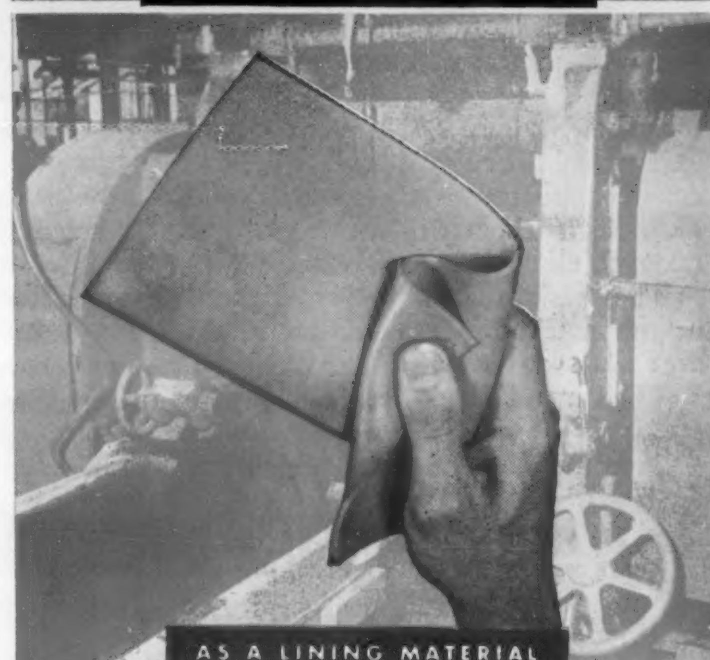
TYGON
THE VERSATILE CORROSION-RESISTANT
PLASTIC

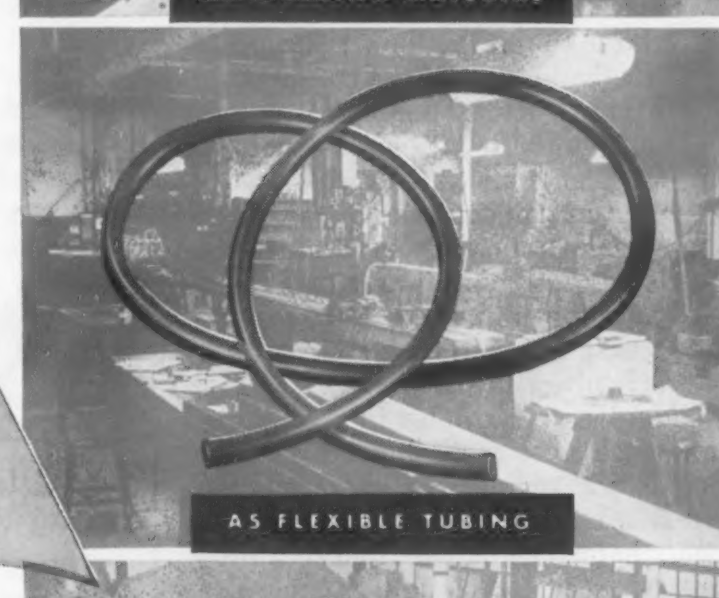
It's worth checking into — one of the many Tygon flexible plastic formulations may well provide the answer to your tough corrosive problems.

U. S. STONEWARE

PLASTICS AND SYNTHETICS DIVISION — AKRON 9, OHIO

AS A PROTECTIVE COATING


AS A LINING MATERIAL


AS FLEXIBLE TUBING


AS GASKETING OR MOLDED PARTS

A REGULAR SERVICE OF THE **COOPER ALLOY** FOUNDRY CO., HILLSIDE, N. J.

Technical Topics

MACHINING 18-8 STAINLESS STEEL --- METALLURGICAL CONSIDERATIONS

Norman S. Mott
Chief Chemist and Metallurgist

Most of the headaches associated with the machining of stainless alloys can be cured with machining experience, but some of them are associated with metallurgical considerations. This applies both to the wrought and the cast materials. Too often the underlying causes and the possibilities for their correction are not well understood. The purpose of this discussion is to review these causes, and to indicate the steps which may be taken to eliminate them.

The basic difficulties experienced in the machining of stainless alloys are:

1. The metal is too hard. . . . The cutting tool cannot penetrate or too much cutting tool pressure is required.
2. The metal is too tough. . . . It tears away instead of breaking up into chips.
3. Frictional or galling characteristics are excessive. . . . Chips adhere to the tip on the tool, resulting in the balling up of the cut metal.
4. Microstructural non-uniformity or segregation. . . . This causes hard spots and results in rough or uneven machined surfaces.
5. The metal work hardens. . . . This results in a blunt tool and a polishing rather than a cutting action. Let us review each of these difficulties in turn:

Hardness: Hardness in 18-8 stainless, such as to cause difficult machining is not an inherent characteristic. It is usually found in the form of work hardening, either from cold rolling or from hot working to too low a temperature. Although machining operations have been conducted up to as high as 350 Brinell, this requires a slow special technique and for practical purposes such hard metal should be soft annealed by water quenching from 1950-2100° F.

Toughness: Correctly heat treated 18-8 stainless in the condition for maximum corrosion resistance is very tough and ductile. These are desirable characteristics from a mechanical viewpoint, but they are pretty tough on machinability. Experience has shown that machining difficulties can be minimized through the addition of an embrittling agent such as selenium, sulphur or phosphorus. And when properly controlled, maximum machinability with a minimum loss of corrosion resistance can be accomplished.

Galling: Galling tendencies, which are associated with softness and ductility, are also largely eliminated by controlled additions of various alloying elements.

Hard Spots: Hard spots are caused by microstructural segregations such as carbides and other hard phases. The machining tool in passing over these areas does not cut properly and gives a raised and usually a glazed surface, producing a so-called "orange peel" effect. Correct quench annealing heat treatment is required in order to eliminate such a condition. Another cause of hard spots may be burnt-in pieces of molding sand, a condition sometimes found in poor quality castings.

Work Hardening: Work hardening is a universal characteristic of the 18-8 stainless steels. Pressure by the machine tool tends to cold work the surface and make it hard. To offset this, there are a number of machinists' tricks which are somewhat beyond the scope of this discussion. (Further data on the machining techniques can be found in J. J. Roberts' paper, "Don't Fear Threading of Stainless.")

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chemical method developed recently by John L. Hague and James I. Shultz of the National Bureau of Standards.

In this NBS method, the cast iron sample is dissolved in hydrochloric acid and the iron removed, after oxidation, as the chloride by ether extraction in a continuous extractor. Magnesium, together with part of the manganese, is then precipitated as phosphate from an ammoniacal citrate solution. After dissolving this phosphate precipitate in diluted acid, the manganese is removed by precipitation with ammonium persulfate as manganese dioxide. The magnesium is then precipitated as the phosphate, ignited, and weighed as $Mg_2P_2O_7$. Finally, the weighed pyrophosphate precipitate is examined for calcium by the sulfate-ethanol procedure, and any necessary weight correction is made.

The reliability of the method was checked by making a number of determinations on several NBS standard samples of iron to which had been added known quantities of magnesium. Between 0.01 and 0.10% magnesium was added, the usual range in nodular cast iron. Calcium and cerium were also added to a few samples, as calcium may be present in some cast irons, and as cerium is sometimes added to induce a nodular structure. Results indicate that the NBS method of determination of magnesium in cast iron is applicable to most plain or low alloy irons, and also that moderate amounts of calcium and cerium do not interfere. Accuracy of the order of 0.002% of magnesium was indicated for the range investigated.

Cobalt Requirements for Porcelain Enameling Reduced

The Government Business Committee of the Porcelain Enamel Institute reports that considerable progress has been made by the porcelain enamel industry in reducing the amount of cobalt required for enameling operations. Formerly 2.2 lb of cobalt per ton of steel were used, but the ratio now has been cut to 1.3 lb of cobalt per ton of steel.

According to a PEI Committee spokesman, these figures were revealed at a recent meeting between

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National Production Authority officials and the Frit Manufacturer's Advisory Committee held recently in Washington. At the meeting it was agreed that porcelain enamelers should supply NPA with figures on how much cobalt is needed and how much finished product can be produced with it, for NPA guidance in studying cobalt needs for defense porcelain enameling operations as well as appliance manufacture.

Cobalt, a critical material in many defense products, is the metal-adhering agent used in the porcelain enamel ground coat. The spokesman for PEI states that a further reduction in the ratio of cobalt to steel is deemed impossible without encountering serious manufacturing difficulties.

Mechanical Descaling Makes a Come-Back

The cooling scale that covers the surface of forged or hot rolled steel is highly objectionable in many subsequent processes. The accepted methods of removing this scale have been almost exclusively chemical processes in the last 50 years. The older idea of mechanical descaling has been undergoing a revival, however, and may displace chemical cleaning in many industries in the near future.

Sulfuric acid descaling was standard procedure in wire drawing before the last war. The cooling scale was hard and abrasive, and the acid dip was considered to be the cheapest and most effective way to remove it before drawing. There were a number of well-recognized disadvantages to this method of cleaning. The acid fumes were extremely corrosive to the equipment and were unpleasant to work near. An even worse headache to many manufacturers was the problem of waste disposal—dumping the acid into streams was usually impossible and treatments to neutralize it or bury it were expensive and ineffective.

These disadvantages were put up with until the war brought shortages of sulfuric acid both here and in Europe. The war also increased the reluctance of manufacturers to waste the iron dissolved by the acid. The

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growth of powder metallurgy also increased the prospective value of mechanically removed oxide scale.

One of the first attempts at mechanical descaling was made during the war by a French wire mill, cut off from sulfuric acid supplies. It worked well and a 100% mechanical descaling process was eventually evolved.

The research that has been done in this country has centered on three general methods. The steel is either flexed, stretched or brushed to remove the scale. Commercial equipment is now being offered to replace the older acid dip methods.

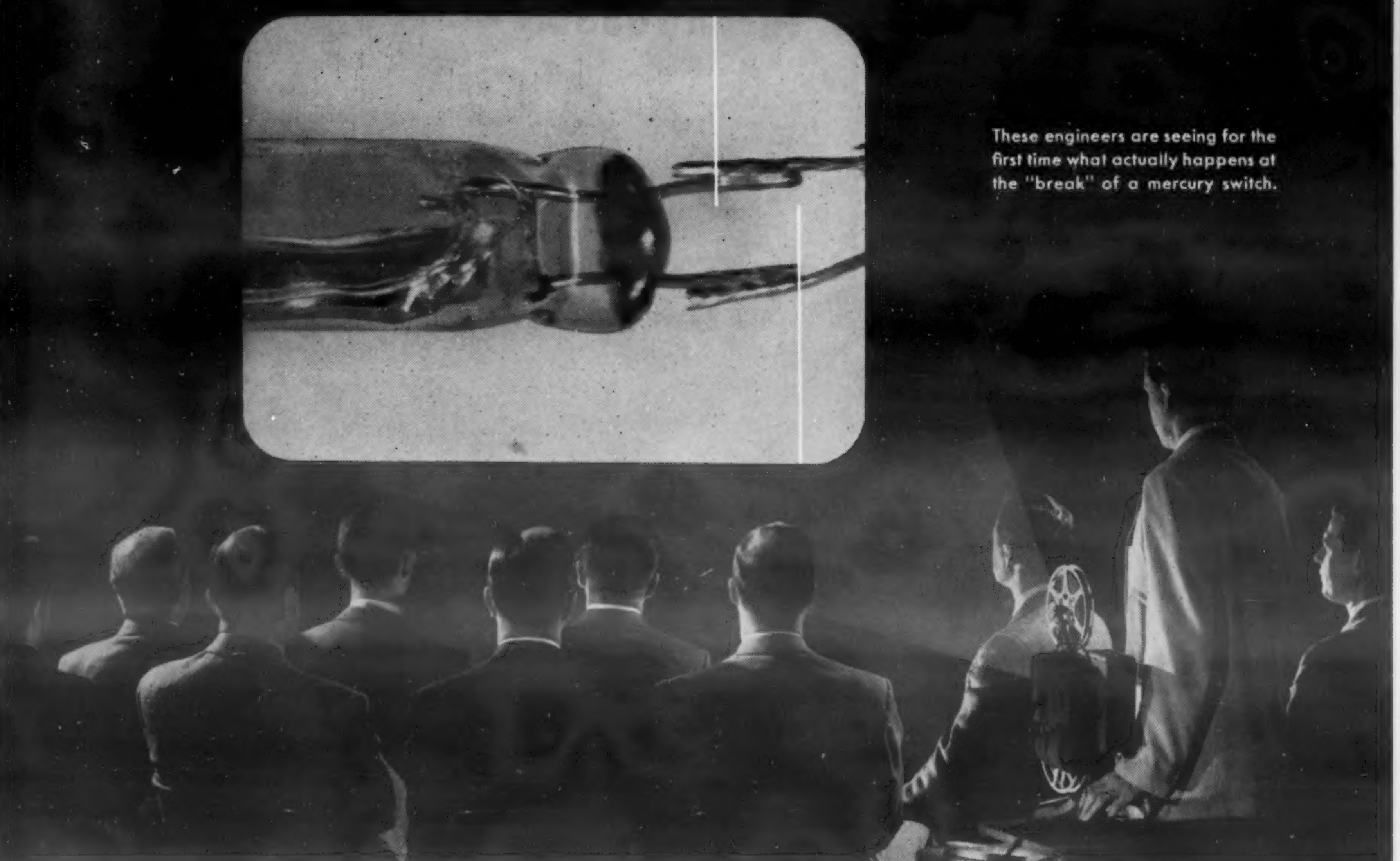
During the past ten years, for example, The Osborn Manufacturing Co., in Cleveland, Ohio, has devoted considerable effort to a project aimed at developing a mechanical method for removing and salvaging cooling scale from the surface of steel strip, bars and rods. This new brushing method would not only remove all the scale but would also improve the surface and the physical characteristics of the article in preparation for further processing, *i.e.* cold rolling, drawing, plating, enameling, etc.

The development work has now progressed to the formulaton of a plan, the elements of which have been sufficiently tested to indicate that the chances of success are excellent.

The equipment needed may occupy very much less floor space than that needed for acid pickling or sodium hydride methods for scale removal. The horsepower consumed by the Osborn method will be considerably less than that consumed by a rolling line, and the amount of power required will depend upon the speed of the operation. The speed can be adequate to meet any mill requirements. Speeds of 200 to 500 ft per min have been studied and judged to be feasible. Higher speeds are well within probability, and are governed only by the type of equipment used.

The virtues of brush descaling include rapid and effective removal and salvage of oxide scale, the removal of slivers, the rounding of sharp edges of pits and scratches which can be objectionable in themselves or as the occasion for the forming of miniature seams and other defects on subsequent rolling. In addition to this, the method reduces the differences in hardness of

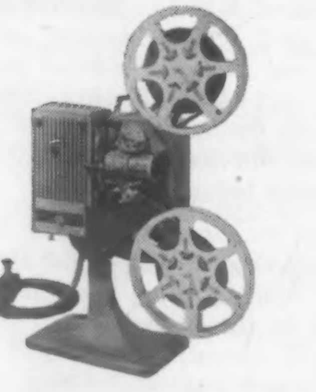
Now... High Speed Movies of Mechanical Action and Oscillograph Traces Combined on One Film!



These engineers are seeing for the first time what actually happens at the "break" of a mercury switch.

The Kodak High Speed Camera can now be supplied with a special feature which permits the recording of cathode-ray oscillograph traces through the back of the film. This makes possible high speed motion pictures of mechanical action with its electrical aspects simultaneously superimposed *on the same 16mm film.* When projected at normal speed, you get a complete picture of combined mechanical and electrical action slowed down as much as 200 times.

This basic improvement has countless new applications for solving design, production, and product performance problems through high speed movies, particularly those involving electrical equipment. Since an argon lamp times the film travel, extremely accurate analysis is possible. This unique tool may be the answer for which you have been looking. Further information and a copy of the booklet "Magnifying Time" will gladly be sent on request.



The Kodascope Sixteen-10R Projector... To show your high speed movies so that you can study the critical phases of action, this moderately priced projector is equipped with a remote-control push button for reversing film direction over and over again. Its 2-inch $f/1.6$ lens and 750-watt lamp assure bright screen illumination, sharp from edge to edge. Important details stand out clearly, even if exposure conditions have not been optimum.

EASTMAN KODAK COMPANY, Industrial Photographic Division, Rochester 4, N. Y.

High Speed Movies

...a function of photography

Kodak

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adjacent regions of the metal, thereby promoting more uniform physical and chemical characteristics. On subsequent rolling or drawing this increased uniformity promotes better results. The increased uniformity also reduces the chemical activity by passivating the surface by mechanical methods. This gives improved results when the surfaces are plated. The avoidance of contact of the steel surfaces with acid and alkali solutions, which this method permits, eliminates factors tending to promote embrittlement and the absorption of gases which, if not properly removed, are detrimental for some purposes, such as enameling, painting, and other operations. The method also permits the removal of edge burrs after trimming or slitting and the rounding of sharp edge markings which otherwise promote edge cracking on subsequent rolling.

News of Engineers

Donald N. Watkins, who had previously been president and treasurer of Laclede-Christy Co., was elected chairman of the board and president at a recent board meeting.

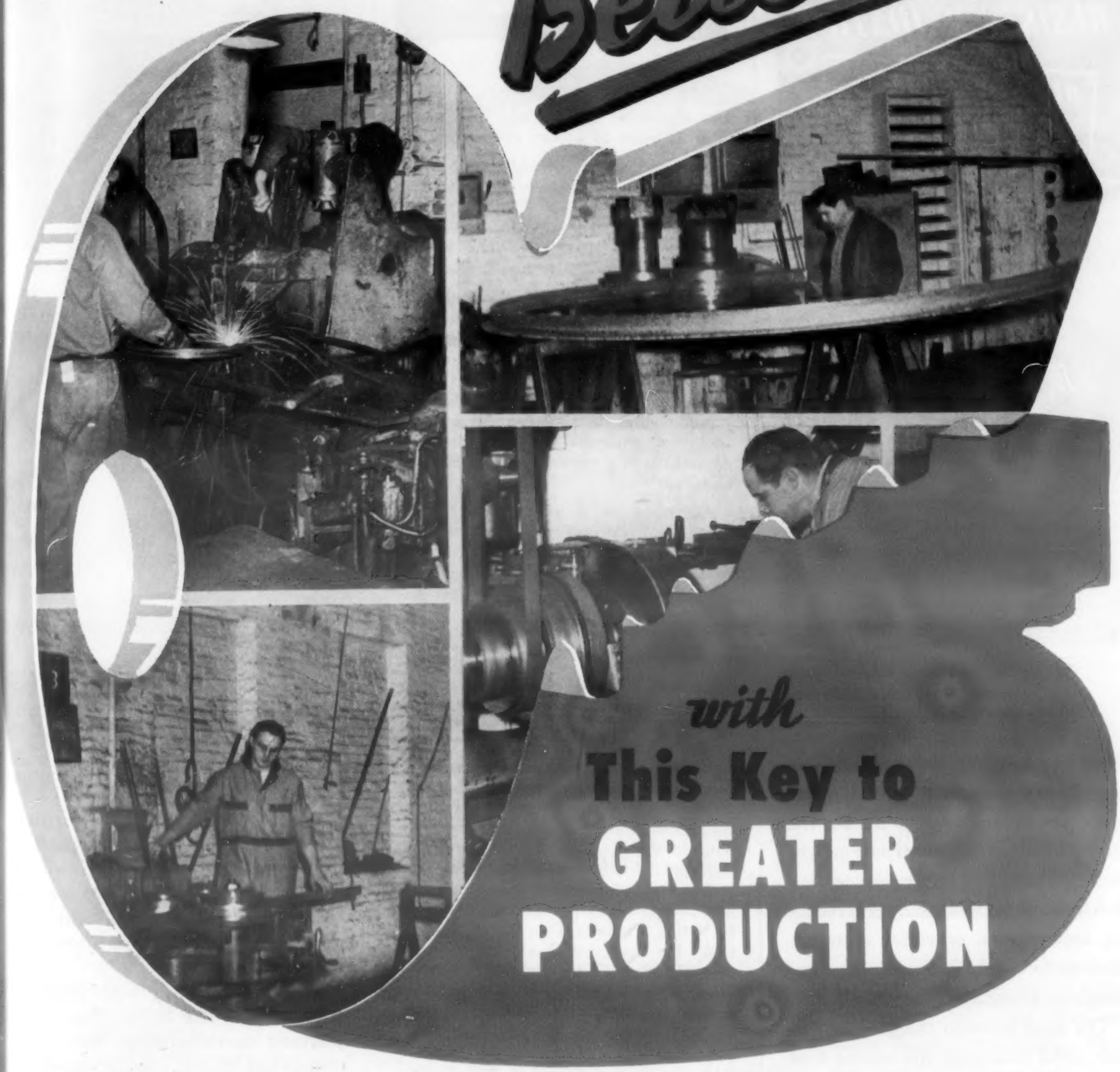
The Bessemer Medal for 1951 was recently awarded to *Benjamin F. Fairless,* president of the United States Steel Corp., by the British Iron and Steel Institute, in recognition of his distinguished services to the industry. The presentation was made at the fifty-ninth general meeting of the American Iron and Steel Institute at the Waldorf Astoria Hotel.

Ideal Plastics Corp. has announced the appointment of *Alfred C. Manovill* as vice president and general manager of the company, and *Lionel Weintraub* as vice president. Mr. Manovill has been associated with the industry since 1924 and is a former director of the The Society of the Plastics Industry.

The appointment of *William S. Renier* as director of engineering of the Hydraulic Press Manufacturing Co. has been announced by the company. Mr. Reiner's position will embrace all phases of engineering research and development of the company's products.

Dr. *Cole Coolidge* has been named director of the Chemical Dept. of E. I. du Pont de Nemours & Co., Inc. Assistant director since 1939, Dr. Coolidge succeeds

LOCK UP THE *Better* JOBS



Stands to reason you can't handle many *more* jobs but you can take on better *quality* jobs . . . jobs which return a better profit . . . jobs which demonstrate your top ability.

Well, you can go after and lock up the better jobs when you select King to supply your ring requirements. King bends and welds from bar stock, bands, flanges, angles, special shapes to your specifications. Make King your ring department. Save time, money, material, labor. A phone call, a wire, a letter will start King working as your Ring Department.

King FIFTH WHEEL COMPANY
2915 N. 2ND ST., PHILADELPHIA 33, PA., NE-4-2444

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Dr. *Elmer K. Bolton,* who has retired after 21 years of service as director.

Appointment of *Arnold M. Wolf* as vice president in charge of manufacturing has been announced by the Lewyt Corp. Mr. Wolf has been works manager of the company since 1942, and has been a manufacturing executive for 20 years.

Donald I. Bohn, chief electrical engineer of Aluminum Co. of America, was recently awarded the 1950 Benjamin G. Lamme Gold Medal by the American Institute of Electrical Engineers. The coveted award is one of the highest bestowed in the electrical engineering field, and was presented at the Institute's general summer meeting held in Toronto, Canada.

According to a recent report from Aluminum Co. of America, *H. V. Churchill,* chief of the Analytical Div. of the company's Research Laboratories, has retired after 32 years of service. Mr. Churchill has been succeeded by his son, *J. R. Churchill,* who has been his assistant since 1944.

General Electirc Co. has reported the following appointments within its organization: *Alan Howard* has been named operation manager for the Gas Turbine Div. and *J. P. Keller* has been named as his assistant. Mr. Howard will have the responsibility for commercial, engineering, manufacturing and accounting functions in the division. *Ronald W. Staley,* of General Electric's Chemical Dept., has been appointed engineering supervisor on new mica products for the Laminated and Insulating Products Div. Dr. *Louis T. Rader* has been named assistant manager of engineering of the company's Control Divs. Appointment of *W. B. Booth* as manager of the company's Pittsfield Ordnance Operation has also been announced. Concurrently, *C. H. Ridgley* of Schenectady, N. Y., was named as Mr. Booth's successor as manager of the Division's Johnson City, N. Y., plant. Three new appointments have been made in General Electric's Aeronautic and Ordnance Systems Divs.: *J. W. Whiteside* was named manager of production; *H. F. Dickie* became superintendent of the Schenectady Aeronautic and Ordnance Manufacturing Div.; and *K. K. Bowman* was named assistant to the manager of manufacturing.

The election of *Larry P. English* as chief engineer has been announced by K S M Products, Inc. Prior to his appointment, Mr. English had been district engineer for the company in the New York and New England area.

Mr. *Glen A. Wilson* has been appointed general superintendent of the Carbide Div. of the Firth Sterling Steel & Carbide Corp., according to a recent company announcement. Mr. Wilson pre-

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viously served the company as chief industrial engineer.

Graver Tank & Manufacturing Co. has announced the appointment of Dr. *Edwin Wetterstrom* to its research and development staff as analytical engineer. Dr. Wetterstrom's duties are to pursue new and independent lines of research in problems of the storage of volatile liquids.

According to a recent company announcement, Mr. *Charles A. Baer* has joined the National Research Corp. as a project manager in its Applied Physics Dept.

Harmon E. Keyes, chemical and metallurgical engineer, has joined the technical staff of Infilco, Inc. as a special consultant. Mr. Keyes will devote himself primarily to the further development of the autoxidation process, a field in which he holds many patents.

G. W. Reese, associated with the American Can Co. for 31 years, has been appointed manager of manufacture, according to a recent announcement. Formerly assistant general manager of manufacture, Mr. Reese succeeds *S. D. Arms*, who was elected vice president in charge of the company's Atlantic Div.

Announcement of the appointment of *Leo F. Brown* as works manager of its Ambridge, Pa., plant has been made by the National Electric Products Corp.

John F. Smith, Jr., general manager of sales, Inland Steel Co., has been granted a six months leave of absence in order to serve as chairman of the Production Directive Committee and assistant director of the Iron and Steel Div. of the National Production Authority. Other announcements from the company make known the retirement of *Crawford B. Murton* as works manager of the organization's Chicago Heights plant and the appointment of *William Porter Goodman*, general superintendent of the plant, to succeed Mr. Murton as chief operating official.

According to a recent company announcement, *Vincent Lysaght* has been appointed sales manager of the Helicoid Gage Div., American Chain & Cable Co., Inc. Mr. Lysaght will continue to serve as sales manager of the Wilson and Campbell Divs.

Detroit Steel Products Company has announced the death of its president, *Wilfred C. Owen*.

J. Gordon Gage, manager of the Butler Div., Armco Steel Corp., died suddenly while playing golf. Mr. Gage was 64 years old, and had served the company since 1910.

The death of *David C. Scott*, an internationally known authority in the field of


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Data Book
NO. 107-C

News Digest

physical testing and president of Scott Tester, Inc., has been announced by the company.

The Cro-Plate Co., Inc. has announced the death of its president, *Theodore L. Brantly, Jr.* Mr. Brantly was killed recently in an automobile accident.

News of Companies

The *Formica Co.* has won top recognition in the second annual Canadian Plastics competition. The 1951 Achievement Award for thermosetting plastic products went to the *Stevens-Hepner Co., Ltd.*, Port Elgin, Ont., for its line of brushes, the backs of which are of Formica age-proof wood.

The *Wel-Met Co.* has announced plans for the construction of an additional plant at Salem, Ind. Estimated to cost upwards of a half-million dollars, exclusive of land and building, the new plant is expected to triple the company's production of self-lubricating bearings and structural and mechanical parts made of sintered metal powder.

Purchase of the *Glenvale Products Corp.'s* Detroit die casting plant by *Universal Die Casting & Manufacturing Corp.*, has been announced by the company's president. The acquisition of this plant is a part of Universal's extensive extension plans.

Uniform Tubes has announced its new location at Collegeville, Pa.

The *Wendt-Sonis Co.* has undertaken an extensive plant expansion program, according to a recent company announcement. The building program now underway will add 16,200 sq ft of working space and is expected to double the productive area of the plant.

Formation of the *Franki Foundation Co.*, which will engage in engineering and installing foundations for industrial and commercial construction has been announced by the newly elected president of the corporation, Arthur J. Bulger. General headquarters have been established at 436 Seventh Ave., Pittsburgh.

To streamline its service to the expanding fruit and canning industries in eastern and central Pennsylvania, and the Appalachian areas of Maryland, Virginia and West Virginia, the American Can Co. has announced plans for a new metal container factory to be located near Harrisburg. The new plant is expected to have a capacity for more than 400,000,000 cans

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a year, and will employ approximately 450 to 475 people.

Battelle Memorial Institute has recently begun construction on the new million-dollar laboratory building. The new laboratory results from increased demands for research services in behalf of the nation's defense effort.

News of Societies

The new laboratories of the *Tin Research Institute* at Greenford, England were opened officially by the Duke of Gloucester, according to a recent announcement. The Institute, which originated in 1927, is a unique example of international collaboration for research.

At the annual meeting of the board of directors of the *American Iron and Steel Institute*, the following officers were re-elected: Walter S. Tower, president; B. F. Fairless, president, United States Steel Corp. and Frank Purnell, chairman of The Youngstown Sheet and Tube Co., vice presidents; George S. Rose, secretary; and Max D. Howell, vice president and treasurer of United States Steel Corp., treasurer. At the Institute's 59th General Meeting, held in the Waldorf Astoria Hotel, Wilbert G. Nichol and Walter N. Flanagan of United States Steel Co. were awarded the American Iron and Steel Institute Medal for 1950. A newly established award, the Regional Meeting Technical Award, also for 1950, was presented to H. E. Warren, Jr. of United States Steel Co. The Gary Memorial Medal for outstanding achievement in the iron and steel industry was also presented at the meeting to Edward L. Ryerson, chairman, Inland Steel Co. Mr. Ryerson is chairman of the Institute Committee on Public Relations.

John C. Cotner, president, Hydraulic Press Manufacturing Co., was elected director of the Machinery Div. of the *Society of the Plastics Industries, Inc.* at the recent annual conference held at White Sulphur Springs, W. Va.

At the annual meeting of the board of directors, Russel B. Caples was elected president of the *American Zinc Institute*. Mr. Caples, manager of the Anaconda Copper Mining Co.'s operations at Great Falls, Mont., succeeds Edward H. Snyder, who has held office since 1949. Three vice presidents were also elected to office: Herman D. Carus, Elmer Isern and G. Howard LeFevre; Erle V. Daveler, American Zinc, Lead and Smelting Co., was re-elected treasurer; and Ernest V. Bent continues as executive vice president and secretary.

Meetings and Expositions

STEEL FOUNDERS' SOCIETY, fall meeting. Hot Springs, Va. Sept. 24-25, 1951.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Petroleum Mechanical Engineering conference. Tulsa. Sept. 24-26, 1951.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Minneapolis. Sept. 26-28, 1951.

ASSOCIATION OF IRON & STEEL ENGINEERS, annual convention. Chicago. Oct. 1-4, 1951.

INDUSTRIAL PACKAGING & MATERIALS HANDLING EXPOSITION. Cleveland. Oct. 1-4, 1951.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Petroleum Branch fall meeting. Oklahoma City. Oct. 3-5, 1951.

PRESSED METAL INSTITUTE, annual meeting. Chicago. Oct. 3-6, 1951.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic, production forum and display. Los Angeles. Oct. 3-6, 1951.

ELECTROCHEMICAL SOCIETY, fall meeting. Detroit. Oct. 9-12, 1951.

PORCELAIN ENAMEL INSTITUTE, annual forum. Columbus. Oct. 10-12, 1951.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Fuels and AIME Coal joint conference. Roanoke, Va. Oct. 11-12, 1951.

METAL TREATING INSTITUTE, annual meeting. Detroit. Oct. 12-14, 1951.

AMERICAN WELDING SOCIETY, annual meeting. Detroit. Oct. 14-20, 1951.

AMERICAN GAS ASSOCIATION, annual convention. St. Louis. Oct. 15-17, 1951.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Institute of Metals Div. fall meeting. Detroit. Oct. 15-17, 1951.

AMERICAN SOCIETY FOR METALS, annual meeting. Detroit. Oct. 15-19, 1951.

NATIONAL METAL CONGRESS & EXPOSITION. Detroit. Oct. 15-19, 1951.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, annual meeting. White Sulphur Springs, W. Va. Oct. 21-25, 1951.

AMERICAN MINING CONGRESS, metal and nonmetallic mining convention. Los Angeles. Oct. 22-24, 1951.

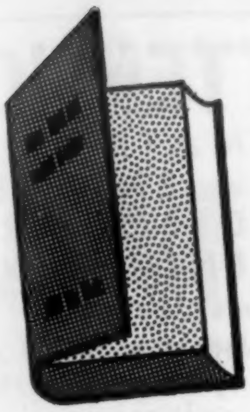
NATIONAL ELECTRONICS CONFERENCE. Chicago. Oct. 22-24, 1951.

NATIONAL STANDARDIZATION CONFERENCE. New York. Oct. 22-24, 1951.

WIRE ASSOCIATION, annual convention. Chicago. Oct. 22-25, 1951.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall meeting. Cleveland. Oct. 22-26, 1951.

GRAY IRON FOUNDERS' SOCIETY, annual meeting. Chicago. Oct. 25-26, 1951.



BOOK REVIEWS

Welding Principles

WELDING PRINCIPLES FOR ENGINEERS. *By Joe Lawrence Morris. Published by Prentice-Hall, Inc., New York 11, N. Y., 1951. Cloth, 6 by 8¾ in., 511 pages. Price $7.00.*

Although the methods of joining metals have been improved greatly during the past few years, welding must still be considered an art rather than a science. In this clearly written book, the author has discussed the status of the art, with emphasis particularly on the underlying principles rather than on practice, an approach which will lead eventually to the growth of the science of welding. The book will appeal particularly to the engineer who requires a sufficiently broad knowledge of welding to select a suitable method but is not concerned with the operation itself.

In a well-organized approach to the subject, the author considers the metallurgical principles involved, discusses the characteristics and applications of the various welding processes and the testing of welds, and reviews the methods generally used for welding the commercial ferrous and nonferrous alloys. Chapters are devoted to surfacing for the production of hard-facings or repair, welding rods, designing for welding, and the economics of the processes. Brazing and soldering, metal spraying, flame heat treating, and the application of the oxygen cutting torch are discussed also. Each of the 13 chapters is followed by a brief bibliography.

It is stated in the preface that the book is intended to serve as a text-book for engineering colleges, and it is admirably suited for the purpose. However, the busy engineer wishing to review a welding procedure or select a process will find this book a valuable addition to his reference shelf.

Structures and Properties of Metals

THE STRUCTURE AND MECHANICAL PROPERTIES OF METALS. *By Bruce Chalmers. Published by John Wiley & Sons, Inc.,*

(Continued on page 178)

Book Reviews

continued

New York 16, N.Y., 1951. Cloth, 5½ by 8¾ in., 132 pages. Price $3.50.

Technical men, familiar with the engineering aspects of metallurgy, *i.e.* the properties of metals and the methods employed to obtain them, but unfamiliar with the atomic structure of metals and alloys and the relations between structure and properties, will find this clearly written book a help in understanding this other, fundamental aspect of metallurgy. The object, as stated, is to provide the simplest possible picture of the structure of metals and alloys and its relation to their mechanical properties. This is accomplished without any resort to mathematics and with some degree, admittedly, of oversimplification.

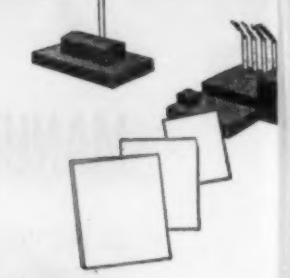
The book starts with a description of the structure of a pure metal, explaining why the structure is orderly and how it is held together. This accomplished, it goes into the various ways in which the structure may be altered, namely by alloying, deforming and heat treating, and explains the effects each produces. A brief, very general chapter describes the methods by which the structure can be analyzed and determined, and can be considered the end of the first part of the book. The last chapter constitutes the second part of the book in which the more important mechanical properties are discussed from the structural point of view, with the aid of numerous examples.

The book is written with the chief aim of presenting as clear and simple a description of the theory of metal structure as possible. For this reason, it should not be expected that the examples chosen to clarify the theory will have much practical usefulness. They were chosen merely for their aptness and without regard for their technical significance.

Other New Books

STANDARD METHODS OF ANALYSIS OF IRON, STEEL AND FERRO ALLOYS. FOURTH EDITION. *Published by The United Steel Companies, Ltd., Sheffield, England, 1951. Cloth, 6¼ by 9¼ in., 169 pages. Price $3.50.* The method of analysis of iron, steel and ferro-alloys described in this book are selected methods which have been adopted by and are actually in use as standard in the laboratories of The United Steel Companies, Ltd. The major addition comprised in this enlarged fourth edition is a new section dealing with physicochemical methods which have proved of great value in service.

SIMPLIFIED MECHANICS AND STRENGTH OF MATERIALS. *By Harry Parker. Published by John Wiley & Sons, Inc., New York 16, N. Y., 1951. Cloth, 5¼ by 8 in., 275 pages. Price $4.00.* This is an elementary treatment written for those who have had limited preparation, but who have not obtained a practical appreciation of mechanics or advanced mathematics. One of the most important features of this book is a detailed explanation of the numerous illustrative examples that are presented.



MANUFACTURERS' LITERATURE

Materials

Irons • Steels

Stainless Steels. Allegheny Ludlum Steel Corp., 34 pp, ill. Fabrication characteristics, available forms, properties and corrosion resistance of stainless steel types. Shows hospital uses. (1)

Aluminum Coated Steel. Armco Steel Corp., 26 pp, ill. Properties and uses of Aluminized steel, and techniques for welding and finishing it. (2)

Tool Steels. Bethlehem Steel Co. Properties, selection data and heat treating information about this company's tool steels. (3)

Stainless Steel Specifications. Peter A. Frasse and Co., Inc., Sec. A, No. 2. Cardboard chart gives Military, Army, Navy and Federal specifications, with corresponding AISI, SAE and AMS numbers, for 37 steels. (4)

High-Strength, Low-Alloy Steel. Jones & Laughlin Steel Corp., 32 pp, ill. Complete data on Otiscoloy, widely used in the transportation industry. (5)

Aircraft Steels. Joseph T. Ryerson & Son, Inc., 68 pp. Correlated Armed Forces, Federal and Aeronautical Materials Specifications plus nearest AISI analyses. Includes available range of sizes and analyses. (6)

Galvanized Steel. Sharon Steel Corp. Brochure summarizes test data on Galvanite, zinc coated steel said to fabricate like ordinary cold rolled steel, resist corrosion for years. (7)

Steels. Timken Roller Bearing Co., Steel and Tube Div., Canton Ohio. Complete catalog of steels produced by this company available upon request on company letterhead.

Alloy Steels. Wheelock-Lovejoy & Co., Inc., 3 pp. Data on AISI, Hy-Ten and SAE alloy steels including composition limits, heat treating instructions, properties and applications. (8)

Nonferrous Metals

Aluminum and Its Alloys. Aluminum Co. of America, 154 pp, ill, No. AD51. Data on aluminum and its alloys, including heat treatment, available forms, design and fabricating practices. (9)

Lead-Base Babbitt. The American Crucible Products Co. Data sheets on properties and applications of Promet XXX, lead-base babbitt said to have qualities superior to tin-base babbitts. (10)

High Density Metal. Fansteel Metallurgical Corp. Bulletin describes Fansteel 77 Metal said to be strong, machinable, useful in rotors and balance weights, have a density close to that of tungsten. (11)

Aluminum Alloy. Frontier Bronze Corp. Data on Frontier 40-E aluminum alloy combining high strength, good shock and corrosion resistance and machinability. (12)

High-Temperature Alloys. Haynes Stellite Div. *Haynes Alloys for High Temperature Service* provides detailed tables and charts on their properties and heat treatment. (13)

Nickel Alloy Corrosion Resistance. The International Nickel Co., Inc., 16 pp, ill, reprint. Corrosion resistance of nickel, Monel and Inconel to soap and fatty acids as compared to other metals. (14)

Aluminum Forging Stock. Reynolds Metals Co., 4 pp, ill, No. AD 400-15-650. Technical data in tabular form including mechanical properties and alloys and tempers of aluminum wire, rod, bar and forging stock. (15)

Nonmetallic Materials • Parts

Carbon Black Dispersions. Acheson Colloids Corp., Dispersal Pigments Div., 2 pp. Descriptions, compositions, uses and handling methods for carbon black dispersions in various plastics and plasticizers. (16)

Porcelain Insulators. The Akron Porcelain Co., 6 pp, ill. Numerous electrical insulators of various porcelains and briefly describes engineering properties of porcelain. (17)

Hard Rubber. American Hard Rubber Co., 60 pp. Manual gives detailed selection data on hard rubber and plastics materials. (18)

Extruded Plastics. The Anchor Plastics Co., 8 pp, ill, No. AP51. Shows numerous applications of extruded thermoplastics and brief characteristics to aid in selection. (20)

Rubber Parts. Automotive Rubber Co., Inc. Series of bulletins show use of rubber for insulation or corrosion prevention in industrial equipment. (21)

Industrial Insulation. Baldwin-Hill Co., 26 pp, ill, No. J-1R. Thermal properties, costs and specifications of insulations for heat treating equipment, ovens and refrigerating units. (22)

Low Pressure Molding Material. Bolta Products Sales, Inc., 4 pp, ill. Specifications, features and applications of Boltaron low-pressure molding material said to be exceptionally durable. (23)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on page 185

Porcelain Products. The Colonial Insulator Co., 12 pp, ill. Shows wide range of custom-made porcelain products, including insulators, forms for dipped rubber goods, and kitchen appliances. (24)

Coated Fabrics. The Connecticut Hard Rubber Co. Uses, chemical, electrical and mechanical properties, and availability of heat resistant silicone rubber coated glass fabrics. (25)

Fabricated Plastics. Continental Can Co., Plastics Div., 28 pp, ill. Describes this company's facilities for the forming and fabrication of thermosetting thermoplastic and laminated plastics. (26)

Commercial Glass. Corning Glass Works, No. B-83. "Properties of Selected Commercial Glasses" gives features of various types of glass and suggests industrial applications. (27)

Rubber Parts. Davidson Rubber Co., 4 pp, ill. Detailed description and specifications of this company's sponge rubber and examples of some of the custom-made rubber products produced. (28)

Plywood. Douglas Fir Plywood Assn., 32 pp, ill. Series of articles shows how to use plywood effectively in fixtures, displays, posters and signs. (29)

Silicone Rubber. Dow Corning Corp., 16 pp, ill, No. F-10. Detailed descriptions of properties, applications and thermal, chemical and electrical resistances of Silastic rubber. (30)

Glass Products. Dunbar Glass Corp., 4 pp, ill. Descriptions of this firm's various industrial glasses. Explains advantages of glass to the designer and gives physical properties. (31)

Plastics. E. I. du Pont de Nemours & Co. (Inc.), 10 pp, ill, No. 113/3. Descriptions, advantages and uses of Lucite, Polythene Nylon, Butacite, Pyralin, Plastacele and Teflon. (33)

Plastics Parts. The Fabri-Form Co., 12 pp, ill. Describes numerous sample parts custom-made of thermoplastic and thermosetting plastics, advantages of plastics and fabricating facilities. (34)

Laminated Plastics Parts. The Formica Co. Catalog gives full information on company's facilities for complete machining of Formica custom-made parts. (35)

Rubber Putty. B. F. Goodrich Co., 2 pp, ill, No. 9765. Uses, advantages and directions for use of Plastikon rubber putty, said to be permanent, water-tight, air-tight and non-hardening. (36)

Molded Plywood. Keller Products, Inc.,

MANUFACTURERS' LITERATURE

12 pp, ill. Booklet describes standard and constantly used die shapes for molding plywood as an aid to designers of molded plywood shapes. (37)

Molded Alkyd. Plaskon Div., Libbey-Owens-Ford Glass Co., 8 pp, ill, No. A-7. Electrical, dimensional and chemical resistance properties, and design data for molded Plaskon alkyds. Gives several case histories. (38)

Carbon Products. Morganite, Inc., 8 pp, ill, No. 1f. Specifications of various carbon bearings and bushings. Also properties of six series of Morganite carbon products. (39)

Molded Rubber Products. Quaker Rubber Corp., 2 pp, ill. Shows examples of molded rubber products this company is able to produce to specification, among other rubber products. (40)

Molded Parts. Resistoflex Corp., 4 pp, ill, No. 4g/3. Properties and uses of this company's custom-molded parts and resinous-lined, reinforced industrial hose. (41)

Molded and Laminated Plastics. The Richardson Co., 4 pp, ill. Describes wide line of Insurok laminated and molded plastics products and facilities to design and fabricate them. (42)

Rubber Package Cushioning. The Sponge Rubber Products Co., 8 pp, ill. Detailed data on features desirable in cushioning materials and properties of various cushioning materials produced by this company. (43)

Molded Ceramics. Star Porcelain Co. Gives technical data on characteristics of molded ceramic products for electrical wiring, electrical heating and special purposes. (44)

Injection Molded Plastics. Tri-State Die Casting Corp. Folder describes this company's facilities for injection molding thermoplastics and for die casting aluminum and zinc to specification. (45)

Rubber Parts. Tyer Rubber Co., 4 pp, ill, No. 1c. Describes design and molding service for rubber parts specified by industry. (46)

Carbon Graphite. U. S. Graphite Co., 4 pp, ill. Describes Graphitar, carbon-graphite nonmetallic that is chemically resistant, self-lubricating, hard, light and won't warp. (47)

Metal Parts • Forms

Die Castings. The Accurate Die Casting Co., 24 pp, ill. Shows company's facilities for producing to order all types of zinc and aluminum die castings. Includes table of alloy properties. (49)

Precision Castings. The Adapti Co., Investment Casting Div. Brochure explains precision casting methods and shows by numerous applications how they are used. (50)

Precision Castings. Alloy Precision Castings Co., 8 pp, ill. Describes frozen mercury process for close tolerance precision casting of parts to order. Shows numerous products. (51)

Aluminum Parts. Aluminum Goods Mfg. Co., 56 pp, ill. Catalog covers extensive production facilities and technical services for producing wide range of parts. (52)

Copper Clad Steel. American Cladmetals Co., 4 pp, No. E100. Describes Electroshield copper clad steel, said to save up to 80% of copper in some uses. Includes properties and indicates uses. (53)

Zinc Die Castings. American Die Casting Institute. Bulletin describes Certified Zinc Alloy Plan, explaining benefits to die casting buyers. (54)

Bonded Metals. American Nickeloid Co., 16 pp, ill. Fabricating information and suggestions, applications and tables of properties and sizes of Nickeloid Metals. (55)

Nonferrous Plaster Mold Castings. Atlantic Casting & Engineering Corp., No. 4. Describes production of copper-base and aluminum alloy "Atlanticastings." (56)

Precision Castings. Austenal Laboratories, Inc., Microcast Div., 16 pp, ill. Describes Microcast Process for manufacture of precision cast parts including specifications and explanation. (57)

Welded Steel Tubing. Brainard Steel Co., Tubing Div., 8 pp, ill. Shows facilities for manufacturing welded steel tubing, its applications, fabrication and specifications. (58)

Steel Tubing. Bundy Tubing Co., 20 pp, ill. Properties, specifications and typical parts of Bundyweld double-walled copper-coated steel tubing. (59)

Stainless Tubing. The Carpenter Steel Co., 16 pp. "Corrosion Notebook" describes general types of corrosion and gives data on corrosion resistance of various types of stainless tubing and pipe. (60)

Thermostatic Bimetal. W. M. Chace Co., 4 pp, ill, No. 1a/10. Properties of thermostatic bimetals and formulae to use in application to temperature responsive devices. (61)

Powdered Metal Parts. Chicago Powdered Metal Products Co., 4 pp, ill. Properties and advantages of Camet custom-molded powdered metal parts. Includes design types. (62)

Heat Resistant Steel Castings. Chicago Steel Foundry Co. Properties of Pyrasteel, chromium-nickel alloy designed for use in high temperature and corrosion resistant castings. (63)

Welded Parts. The Cleveland Welding Co., 8 pp, ill, No. W-500. Features and inherent advantages of Cleve-Weld circular, circular rolled and welded parts and facilities for making them. (64)

Corrosion Resistant Alloy Castings. The Cooper Alloy Foundry Co., 4 pp. Indicates resistance of corrosion resistant casting alloys against approximately 400 corrosive chemicals. (65)

Perforated Metals. Diamond Mfg. Co., 24 pp, ill, No. 35. Uses, advantages and specifications of various types of perforated metals. (66)

Plastic Lined Fittings. The Dow Chemical Co., 32 pp, ill, No. SL6-N-250. Properties, design data and applications of Saran lined steel and iron pipe fittings and valves. (67)

Corrosion Resistant Castings. The Duraloy Co., 16 pp, ill, No. 3150-G. Describes facilities for manufacture of chromium iron and chromium-nickel castings. Gives detailed properties of alloys and their uses. (68)

Die Cast Parts. The Electric Auto-Lite Co., Die Casting Div., 16 pp, ill, No. G137. Describes facilities for economical manufacture of quality die castings. (69)

Metal and Plastics Parts. The Electric Auto-Lite Co., Bay Mfg. Div., 16 pp, ill. Shows wide variety of custom-made ornamental and functional metal and plastics parts. (70)

Investment Castings. Engineered Precision Casting Co., 4 pp, ill. Describes Epco Precision Investment Castings. (71)

Alloy Steel Tubing. Globe Steel Tube Co. Catalog describes available types of this company's seamless and welded alloy and stainless steel tubing. (72)

Investment Castings. Gray-Syracuse, Inc., 4 pp, ill. Various parts of precision-cast brass, bronze, beryllium copper and steel. (73)

Zinc Die Castings. Gries Reproducer Corp., 4 pp, ill. Specifications of corrosion resistant nonferrous zinc alloy wing nuts, small zinc die castings and injection moldings. (74)

Castings. Hunt-Spiller Mfg. Corp., ill. Folder describes modern facilities for producing iron, steel and alloy castings to customers' specifications. (75)

Permanent Magnets. Indiana Steel Products Co., 34 pp, *Permanent Magnet Manual* No. 3. Uses, types and material of permanent magnets. Includes design data. (76)

Powdered Metal Parts. Keystone Carbon Co., Inc., 36 pp, ill. Describes successful applications of powder metallurgy, gives data on correct design of powdered metal parts and detailed information on powdered metal bearings. (78)

Metal Rings. King Fifth Wheel Co. Catalog and capacity charts of this company's facilities for bending and welding metal rings for industrial purposes. (79)

Aluminum Extruded Shapes. Light Metals Corp., 6 pp, ill. Shows facilities for producing to order a variety of indicated aluminum fabrications and extruded shapes. (80)

Deep-Drawn Shapes. Linde Air Products Co. Complete information on Presto-O-Lite deep-drawn shapes and shells including applications and design aids. (81)

Powder Metal Parts. Metal Powder Products, Inc., 2 pp, ill. Lists types of metal powder parts this company manufactures

to order, their cost-saving advantages. (82)

Die Castings. Monarch Aluminum Mfg. Co. File data on aluminum and zinc die castings and aluminum mold castings showing applications, advantages and this company's facilities for making them. (83)

Precious Metal Parts. The J. M. Ney Co., No. R-12. Technical data on use of precious metals for contacts, brushes, wipers, slip rings and similar components of electrical apparatus. (84)

Corrosion Resistant Castings. The Ohio Steel Foundry Co., 4 pp, ill, No. FC-350. Shows numerous stainless steel castings exemplary of the parts that can be cast by this company. Table of alloy specifications included. (85)

Powdered Metal Parts. Plastic Metals Div., 4 pp, ill, No. 567. Describes applications, advantages and limitations of powder metallurgy as used by this firm for custom-making parts. (86)

Stainless Steel Products. Schnitzer Alloy Products Co., 48 pp, ill, No. 50. Sizes, specifications and corrosion data on such stainless products as machine screws, nuts, pipe and tubing. (87)

Spun Metal Parts. Spincraft, Inc., No. 3. Data book on metal spinning and fabricating gives data on process and help in designing for economical production. (88)

Stainless Steel Castings. The Stainless Foundry & Engineering Co., 4 pp, ill. Shows variety of stainless castings and includes helpful engineering data. (89)

Cast-Weld Construction. Steel Founders' Society of America, ill. Outlines numerous examples of leading founderies' application of cast-weld construction to obtain metals savings and production economies. (90)

Aluminum Bonded to Steel. Arthur Tickle Engineering Works, 8 pp, ill. Describes process for molecular bonding of aluminum to iron and steel, its applications and advantages. (91)

Stainless Tubing. Trent Tube Co. *Trentweld Data Bulletin* describes Trentweld stainless steel tubing, machine formed and welded in wide range of sizes. (92)

Cast Steel Parts. Unitcast Corp., Steel Casting Div., ill, No. 350. Folder illustrates numerous tests to which steel castings are submitted to maintain quality production. (93)

Light Metal Shapes. R. D. Werner Co., 4 pp, ill. Explains relative merits of cold roll forming and extruding light metal shapes. Shows company's facilities for both types of fabrication. (94)

MANUFACTURERS' LITERATURE

Spun Tubing. Wolverine Tube Div., 28 pp, ill. Advantages and numerous applications of this firm's nonferrous Spun End Tube Process. (95)

Coatings • Finishes

Surface Coating Resins. American Cyanamid Co. Properties, compatibility and drying schedules of alkyd, formaldehyde, phenolic and dibasic acid resins for use on surface coatings. (96)

Zinc-Plate Bright Dip. The Chemical Corp. Information on Luster-on Utility-25 bright dip for zinc-plated surfaces. Highly resistant to corrosion. (97)

Metallizing. Metallizing Engineering Co., 4 pp, ill, No. 45A/2M. Case histories and descriptions of three Metcolizing processes indicating protective advantages for typical applications. (98)

Silicone-Base Finish. Midland Industrial Finishes Co. Brochure describes silicone-base finish said to resist heat of 500 F without discoloration. (99)

Corrosion Resisting Coatings. Parker Rust Proof Co., 44 pp, ill, No. A1222. Detailed description of Bonderizing methods and applications and test results showing effectiveness in protecting metals against corrosion. (100)

Methods and Equipment

Heat Treating • Heating

Controlled Atmosphere Furnaces. Delaware Tool Steel Corp., 16 pp, ill. Constructional features and principle of operation of this firm's controlled atmosphere furnaces. (101)

Controlled Atmosphere Furnace. Dow Furnace Co., 4 pp, ill. Data on batch-type controlled atmosphere furnaces for gas cyaniding, carburizing and other operations. (102)

Conveyor Furnaces. The Electric Furnace Co. Descriptions of EF chain belt conveyor furnaces for continuous, low cost heat-treatment of small and medium size parts. (103)

Electric Muffle Furnaces. Harper Electric Furnace Corp., No. 346. Features and specifications of this company's line of electric muffle furnaces for such uses as heating and annealing. (104)

Heat Treating Fixtures. Hoskins Mfg. Co. Catalog shows various heat treating fixtures, baskets, etc., made from heat resistant alloys. (105)

Mold Heating Units. Improved Paper Machinery Corp., Plastic Molding Machinery Div., 1 p, ill. Specifications and descriptions of Models 1 and 2 mold heating and circulating units. (106)

Endothermic Generators. Ipsen Industries, Inc., 2 pp, ill, No. G-15. Shows automatic endothermic generators having capacities of 500 and 1000 cu ft per hr. (107)

Immersion Melting Pots. C. M. Kemp Mfg. Co. Technical data on this company's immersion melting pots for melting soft metals with maximum efficiency, good heat control. (108)

High Frequency Heating Unit. Lepel High Frequency Laboratories, Inc., No. MM-11. Shows low cost, high frequency unit for such jobs as brazing, soldering and annealing. (109)

Heat Treating. Lindberg Engineering Co., 4 pp, ill. Heat Treating Hints describes various heat treating applications and practices utilized by various plants to save

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Brass Cake Heating Furnace. W. S. Rockwell Co., 2 pp, ill, No. RF-6. Technical description of this firm's continuous cycle furnace for heating brass cakes. Includes specifications. (112)

Heat Treating Equipment. Rolock, Inc. 36 pp, ill, No. B-7. Complete line of metal carriers for such operations as quenching, tempering, carburizing and metal cleaning. (113)

Ammonia Dissociators. Sargeant & Wilbur, Inc., 4 pp, ill, No. A.D.10. Features, specifications and applications of a variety of this company's ammonia dissociators. (114)

Heat Treating Equipment. Sunbeam Corp. Sunbeam Stewart Industrial Furnace Div., 4 pp, ill, Vol. 10, No. 6. *Metal Minutes* shows various applications of this company's equipment in user's plants. (115)

Tool Room Furnaces. Surface Combustion Corp., 4 pp, ill, No. SC-151. Describes standard furnaces and atmosphere generators equipped to meet heat treating requirements of tool rooms. (116)

Electric Immersion Heaters. Edwin L. Wiegand Co., 48 pp. Catalog shows complete line of chromalox electric heaters giving applications and specifications. (117)

Cleaning • Finishing

Buffing and Polishing Machine. Acme Mfg. Co. Descriptions and features of this firm's automatic buffing and polishing lathes for rapid finishing of parts in quantity. (118)

Blast Cleaning Equipment. American Wheelabrator and Equipment Corp., 4 pp, ill, No. 584A. Shows various blast cleaning units, describes uses and gives case histories indicating economic advantages. (119)

Abrasive Stone. Elgin National Watch Co., Industrial Products Div., 1 p, No. 101. Price list of silicon carbide and aluminum oxide abrasive stones for stoning tools and dies, prefinishing and changing molds. (121)

New Equipment for Coating. The Gyromat Corp., 4 pp, ill. Describes Norris Gyromat, centrifugal spraying machine said to apply standard industrial coatings and finishes faster, more economically. (122)

Processes for Coating Plastic. Monsanto Chemical Co., Plastics Div., 28 pp, ill. Data on such surface treatments for Lustrex styrene plastic as metallizing, lacquering, stamping and printing. (123)

Metal Cleaning. Northwest Chemical Co., 2 pp. Describes "Lo-Hi" two-tank process for the preparation of metals for plating and vitreous enameling. (124)

Industrial Brushes. Pittsburgh Plate Glass Co., Brush Div., Dept. W-4, 3221 Frederick Avenue, Baltimore, Md. Case histories indicate economies available to users of Pittsburgh brushes. Request on company letterhead direct from this company.

Mechanical Finishing. Roto-Finish Co. Folder describes uses and economies of Roto-Finish tumbling-type equipment for precision grinding, deburring and coloring metals. (125)

Tumbling Barrels. Tumb-L-Matic, Inc., 2 pp, ill, No. LS-50. Features and specifications of Lupomatic dry process tumbling barrels for cutting down, deburring, burnishing metal and plastics parts. (126)

Hard Chrome Plating Unit. Ward Leonard Electric Co., 4 pp, ill. Features of Model A-20 Chromaster industrial hard chrome plating unit, description of process and Chromasol solution. (127)

Welding • Joining

Spot Welding Schedules. Ampco Metal Inc. Reference chart gives recommended schedules for spot welding low carbon steels. (128)

Stainless Fastenings. Anti-Corrosive Metal Products Co., Inc., 80 pp. Catalog indexes and prices over 7000 varieties of stainless steel screws, bolts and other fasteners. (129)

Metal-Cutting Electrode. Eutectic Welding Alloys Corp., 2 pp, ill. Describes new metal-cutting electrode designed for rapid, easy and low-cost metal cutting. Includes prices. (130)

Rivet-Type Fasteners. B. F. Goodrich Co., Rivnut Div., Cardboard "demonstrator" illustrates working principle of Rivnuts, their construction and applications. (131)

Fasteners. The H. M. Harper Co., 134 pp. Shows 7000 sizes and types of bolts, nuts and rivets of brass, bronze, copper, monel and stainless steels. (132)

Welding Nickel Alloy. Illium Corp., 4 pp, No. 105B. Instructions for metallic arc and oxyacetylene gas welding of Illium, nickel-base, corrosion resistant alloy. (133)

Series Arc Welding. The Linde Air Products Co., 26 pp, ill. Detailed theory, advantages, limitations and techniques of series arc welding. (134)

Welded Assemblies. The R. C. Mahon Co., 1 p, ill. Shows several examples illustrating the capabilities of welding for construction of various assemblies. (135)

Weld Screws. The Ohio Nut and Bolt Co. List of stock sizes of weld screws for spot and projection welding made of low carbon steel, brass or stainless steel. (136)

Self-Locking Fasteners. The Palnut Co., 1 p, ill. Describes self-locking machine screw Palnuts, coil tube fasteners, shield can fasteners and acorn Palnuts. (137)

Bolts, Nuts & Studs. Pawtucket Mfg. Co., 28 pp, No. 46. Complete price catalog of this company's fasteners of brass, bronze, stainless steel and monel. (138)

Bench Welder. Raytheon Mfg. Co., 6 pp, ill, No. DL-W-223. Specifications and descriptions of various bench model AC arc welders said to require relatively small amounts of input power. (139)

Fasteners. Simmons Fastener Corp. Literature describes fasteners especially designed for use in construction where easy demountability is required. (141)

Adjustable Fasteners. South Chester Corp., Southco Div., 4 pp, ill. Describes adjustable door fasteners for machinery doors. Said to be applicable quickly and resist loosening due to vibration. (142)

Carbon Arc Welding. Speer Carbon Co., 8 pp, ill. Advantages of carbon arc welding for fabricating and repairing alloy and nonferrous metals. (143)

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Resistance Welding Control. Westinghouse Electric Corp., No. B-4309. Advantages, features and specifications of this company's resistance welding control apparatus. (145)

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Flame Cutting Machine. Air Reduction Sales Co., No. ADC-660. Features of Airco No. 3 Monograph gas shape cutting machine said to be low cost, portable, accurate and highly versatile. (146)

Plastics Molding. The Grigoleit Co. Folder describes this company's facilities for producing molded plastics. Includes designing, engineering, tooling, molding and finishing. (147)

Powder Metallurgy Presses. Kux Machine Co., ill. Catalog shows complete line of presses designed for powder metallurgy giving specifications and features. (148)

Plastics Molding Press. F. J. Stokes Machine Co., 4 pp, ill, No. 503. Description and specifications for automatic plastics press. Typical products shown. (149)

Drilling Machine. Wales-Strippit Corp., 8 pp, ill, No. DM. Describes features, setting up, operation and accessories of Wales drilling machine, designed for precision location of holes. (150)

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Accelerated Weathering Device. Atlas Electric Devices Co., 4 pp, ill. Features and description of Type XW Weather-Ometer for accelerated, controlled weathering tests. (151)

Laboratory Microscopes. Bausch & Lomb Optical Co., 24 pp, ill, No. D185. Descriptions and specifications of various microscopes for such uses as metallurgical microanalysis. (152)

Centrifugal Classifiers. Federal Classifier Systems, Inc., 6 pp, ill, No. 5. Describes this firm's centrifugal air classifiers for accurately controlling sizes of pulverized particles such as powdered metals. (153)

Pocket Thickness Gauge. Ferro Enamel Corp. Full details on pocket-size thickness gauge permitting quick measurement of nonmagnetic coatings on ferrous surfaces to accuracies of 5%. (154)

Temperature Controls. Claud S. Gordon Co., 4 pp, ill. Data on specifications and advantages of Xactline indicating and recording temperature controls. (155)

Flowmeter. Illinois Testing Laboratories, Inc., No. 2448-G. Descriptions and prices of Alnor Velometers for such uses as measuring the velocity of gas flow in furnaces. (156)

Bend Test Machine. Krouse Testing Machine, 4 pp, ill, No. 46-W. Specifications and description of high capacity repeated bending machine. (157)

Spectographs. National Spectrographic Laboratories, Inc., 4 pp, ill, No. 300. Descritpion, operating principle and control features of spectograph units for both quantitative and qualitative analysis. (158)

X-ray Equipment. Picker X-ray Corp., 8 pp, ill, No. 21250. Describes complete line of X-ray equipment from 50 Kv to 24,000 Kv. Includes complete accessories and protective equipment. (159)

Tensile Tester Machines. Scott Testers, Inc., 6 pp, ill, No. 50. Shows wide assortment of testing machines for testing tensile strength of materials such as rubber, paper, wire and thread. (160)

Ultrasonic Thickness Gage. Sperry Products, Inc., 4 pp, ill, No. 3700. Description and basic theory of Reflectogage ultrasonic thickness tester and flow detector. (161)

Moisture Meter. Tagliabue Instruments Div., 6 pp, ill, No. 1295. Design and construction features of Tag Midget Moisture Meter for testing moisture in wood and plaster. (162)

Portable Pyrometers. Wheelco Instruments Co., 4 pp, ill, No. PPY-1. Applications and features of this company's portable pyrometers and thermocouple holders. Includes price list. (164)

General

Rust-Preventive Wrapping. Angier Corp., 20 pp, ill. Numerous applications of wrapping paper impregnated with chemical corrosion inhibitor indicating excellent protection. (165)

Ultrasonic Equipment. The Brush Development Co., 4 pp, ill, No. F-267. Uses and specifications of Hypersonic Equipment for such uses as emulsification, dispersion and degassing. (166)

High Speed Movies. Eastman Kodak Co., Industrial Photographic Div. "Magnifying Time" discusses features of new camera permitting high speed electrical and mechanical visualization of various processes. (167)

Underground Corrosion Protection. Federated Metals Div., folder. Discusses causes of underground corrosion and describes magnesium anodes for giving long-term protection. (168)

Chain and Belt Conveyors. Michigan Steel Casting Co., 8 pp, ill, No. 1-B. Shows Misco rivetless chain conveyors and Woodman belt conveyors for high temperatures. (169)

Materials Controls. Remington Rand Inc., No. KD367. Booklet describes Kardex system for keeping visible materials and parts inventories coordinated with production. (170)

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Unichrome Clear Dip Finish for zinc plate with an application of Unichrome Coating B-115 provides a system with excellent corrosion resistance and appearance similar to chromium.

Or by depositing bright chromium from the Unichrome S.R.H.S.Chromium Bath over thin nickel or no nickel at all, and then using Coating B-115 for extra corrosion resistance, you'll also get a dependable bright finish.

Remember, in United Chromium you have the Company that knows *metal* finishes as well as their requirements in *coatings*. Consult us to learn how Unichrome *combination* finishes can solve your problem.

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A large automotive supplier is producing a yellow, iridescent, corrosion-inhibiting finish on zinc these days with more ease and less expense. Since switching from a "home made" chromate solution to a Unichrome Dip, the Company reduced material costs alone by nearly a third. And there's less trouble getting as good or better corrosion resistance than specified.

As this case indicates, UNICHROME DIPS provide a means of meeting chromate treating specifications for both civilian and defense production with easy-to-use, long-life, economical solutions.

ANOZINC* is still another process used for chromate-treating of zinc. It's especially suited for mass production, where it offers even greater economies.

**Trade Mark*

Dips Do the Job Chemically

The various Unichrome Dips form their conversion coatings *fast*. A simple 5-second to 2-minute immersion does it, producing a surface finish integral with the zinc. You can get *black, olive drab, brass-color, iridescent yellow,* or *clear* finish from solutions which are easy to control.

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Anozinc uses conventional plating equipment and gives you a chromate finish with superior corrosion resistance and extra toughness. Parts can be handled wet, eliminating need for drying time and space. Three Anozinc finishes available — *black, yellow* or *clear* — from solutions that have long, trouble-free life.

* * *

Shell cases, propeller blades, bolts, screws, pump and carburetor die castings and many other parts are today getting the benefits of one of these Unichrome Dip or Anozinc finishes. If you want an economical answer to your own finishing problem, investigate them. Write for data.

Plating Hard Chromium in S.R.H.S. Bath continues to save time . . . Time . . . TIME!

Practically "on the double," the Unichrome S.R.H.S. Chromium Solution is speeding along vital defense production work. Look at some of the records rolled up:

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These were all accomplished by using the Unichrome S.R.H.S. Chromium Solution instead of ordinary chromium. And that's not all. S.R.H.S. Chromium also offers you smoother plate, better leveling action, and self regulation. Ask us about it.

Advertisers and their Agencies

The Editor's Page

Horse of a Different Color

As we have reported before, we're always glad to hear from our readers. At times we pull up short when faced with some of the letters, and still others cause deep-seated chuckles. One of the latter reached us recently, postmarked "Sweet Grass Palomino Ranch, Melville, Montana". It read in part:

"In 1938 I left the research department of the Youngstown Sheet & Tube Co. I have since operated my own ranch here in Montana, where we breed palomino saddle horses. I find MATERIALS & METHODS a good means of keeping in touch with developments in my former line of endeavor, although I can't truthfully say it helps me directly in milking cows or laying out irrigation systems. I do not read every issue from cover to cover, but I do always find something of interest."

Richard Eurich goes on to make a few suggestions which we are seriously considering.

Accommodating Fellows

Recently we had an opportunity of making the $2.40 (including tax) tour of Aberdeen Proving Grounds. There were many marvelous things to see, but one which impressed us most was a sign we passed on the way out. Nicely lettered, and not too obvious, the sign was posted near the door of a small military building. It read: "Civilian Employees Furloughed to the Armed Forces".

No Big Boom

Prospects of our trip to Aberdeen, scheduled as it was shortly after that of President Truman, led us to expect a bang-up show with all the big guns popping. Evidently the officials felt that we weren't worth all that expense, or else they took the flattering attitude that we were too intelligent to be impressed with a lot of noise. At any rate, all we saw fired were a few 30-cal. rifles, but we did see most of the scientific facilities of the installation.

All That Is Gold Does Not Glitter

At the recent ASTM meeting in Atlantic City, one of the speakers in commenting upon the materials shortage said that we should look upon all metals as precious. I think the man had something there, for if our world-wide armament race continues, the materials supply will be one of the major keys to superiority.

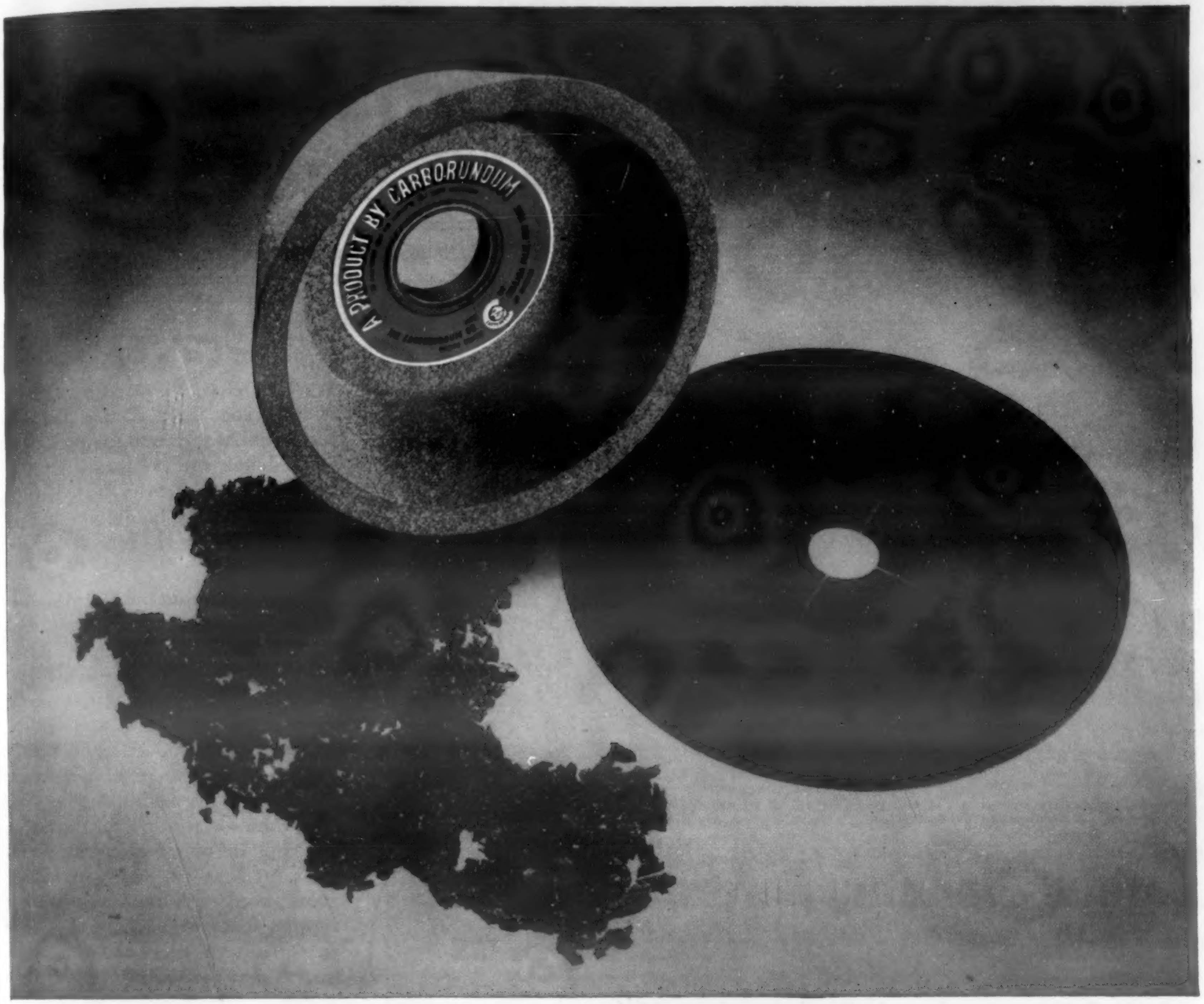
Four S's of Materials

For a long time there has been a saying about good grooming which includes the four "S's"—shave, shine, shower and shampoo. Now comes the same number of "S's" as a guide to saving materials. They are—standardization, simplification, substitution and salvage.

Starting Action

One of the chief uses of a technical magazine is to spread new information and ideas. However, publication of such information is useless unless the readers take some direct action. Therefore, we are always glad to hear that our material has had some direct effect in helping someone. Some years ago, we understand, something we published resulted in the largest single order for resistance welding machines ever placed up until that time. More recently, we told in an article how several GM divisions saved materials—and money—by utilizing every piece of material to the fullest extent. On top of that, proper salvage methods used everything but the squeal. Upon reading the article, the chief materials engineer of a large West Coast aircraft manufacturer phoned for an appointment, flew east and spent several days learning the tricks. When we hear things like these we feel that our editorial judgment has been sound and our readers treated as they should be.

T. C. Du Mond
Editor



Which would you use?

Abrasive wheel, disc or grain — which would you use on any specific metalworking operation? The choice, of course, depends on the material to be removed, desired finish, cost factor and other variables.

Equally important it depends on *improvements in abrasive products and methods* which can make a change to a different type of abrasive advantageous for particular applications.

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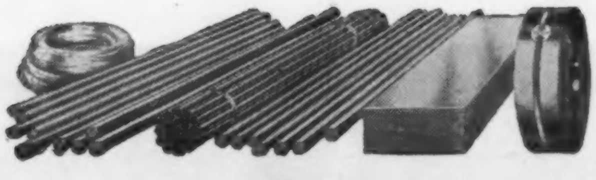

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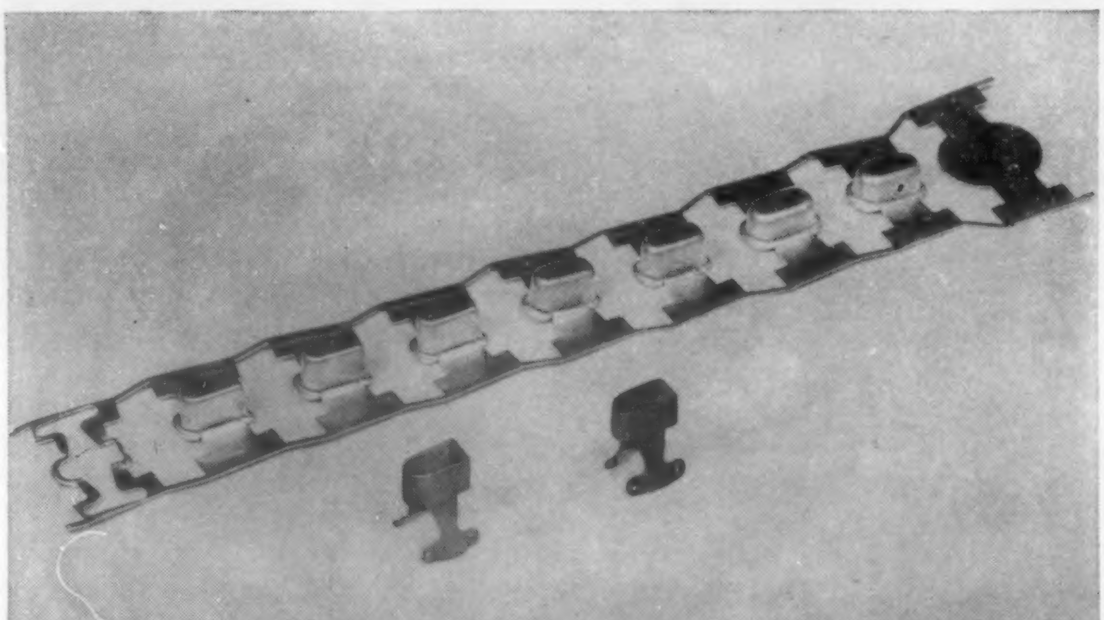

Showing progressive operations in the manufacture of clamp for telephone headset jack. Courtesy, Connecticut Telephone and Electric Corporation, Meriden, Connecticut.

Careful Planning Before Production
Avoids Trouble in Deep Drawing Brass

As in all things, experience in the deep drawing of brass and other copper-base alloys is the best teacher. The reshaping of flat metal into various cup-shaped objects on an efficient production basis is an intricate procedure, and involves skills and know-how. It is, therefore, wise to investigate the problem carefully before attempting to go into production. Help for the determination of the proper alloy for the particular job, and often suitable fabricating techniques as well, can be obtained from our Metallurgical Laboratory and from our literature such as Bridgeport's "Technical Handbook."

The illustration shows the progressive operations used in the production of a clamp for a telephone headset jack. This involves the deep drawing of a rectangular cup, which is not easy. Secondary blanking operations on the bottom of the cup and the formation of the brackets are shown in the small samples in the foreground. Considerable experimental work was done and further developments of the tools were necessary, which involved making two draws to obtain sufficient depth of cup. It was also found advisable to increase the width of the strip metal. The change to a lard oil lubricant was also helpful.

Factors to Consider

The following check-list should be helpful in demonstrating the various points which must be carefully considered before drawing work is actually begun.

1. *Stock* — The flat metal must be wide enough to compensate for contraction of the blank during cupping. Alloy, gauge, tolerance requirements; temper; diameter of arbor are essential.

2. *Punch and Die Radii* — Normal die radius is between 5 and 10 times the thickness of the metal. Too large or too small a die radius may cause trouble.

3. *Die Finish* — Careful polishing of the die is important, since there is a great deal of motion between the metal and the die. Dies should be lapped in the direction of metal flow.

4. *Blank Holder Pressure* — If the blank is not held tightly, the circumferential forces in the perimeter of the blank will produce wrinkling. If blank holder pressure is too great, thickening of the blank will be prevented, and may result in fracturing of the cup.

5. *Diameter Reductions*—In the production of a normal cup for redrawing, the most satisfactory diameter reduction ranges between 40 and 46%. This produces a cup about equal in height and diameter. In making greater reductions, difficulty is encountered in regulating blank holding pressures, and there is danger in the softer alloys of fracturing the cup. In progressive die operations, such as the clamp described above, successive redraws after the cupping operation are held to approximately 15%, since there are no intermediate anneals.

6. *Lubricants*—A lubricant must be used to reduce friction to a minimum and prevent metal-to-metal contact. It must first wet the surface thoroughly, and have sufficient body to stay in place under forming and drawing pressure. The choice of lubricant for a job depends on several factors, including the severity of work, equipment used, production run, means of application and cost. Usually simple soap solutions are satisfactory, but lard oils, vegetable oils and other lubricants are often used.

7. *Metal Surface Finish*—This is important especially in deep drawing operations such as in progressive and eyelet types of work.

This list is intended simply to point out some of the factors influencing success in drawing. Specific problems naturally arise in every individual job. Bridgeport will be glad to help customers with these problems by sharing its vast reservoir of experience acquired in the production and fabrication of copper-base alloys. (6831)